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BALANCE AND BILATERAL SKILLS OF SELECTED PREVIOUSLY DISADVANTAGED CHILDREN AGED 9 TO 12 YEARS

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ABSTRACT

The main aim of the study was to design an appropriate motor skills development programme that could be implemented in any primary school to improve the fundamental motor skills (FMS) of children between the ages of 9 and 12 years old. One previously disadvantaged (Quintile 2) school in the Stellenbosch region was selected to participate in the study. The children (N=67) were conveniently selected to participate in the study and were divided into an experimental (n=35) and a control group (n=32). Only the experimental group participated in the motor skill development programme for 12 weeks. No significant differences were found for the mean balance score within the experimental and the control group or between the pre- and post-test. However, there were significant differences found for the mean bilateral coordination scores between the pre- and post-test of the experimental group but not with the control group. This could be attributed to the 12-week intervention programme presented to the experimental group. It is suggested that this programme may be beneficial to all primary school children, not only those from previously disadvantaged schools.

Key words: Balance; Bilateral coordination; Children; Fundamental movement skills.

INTRODUCTION

Movement is such a natural part of a human‟s daily life that the importance thereof is often overlooked. It is, however, vital for the development of a child‟s physical, cognitive and social characteristics (Cools *et al*., 2009). Many children who appear to be „normal‟ at first sight might experience complications with the acquisition and performance of basic motor skills. These children are often described as clumsy and the cause of the impaired motor performance is usually ascribed to an underlying problem that is not always easy to observe (Smyth, 1992; Hands, 2012).

In order to execute motor skills successfully, the child needs well developed balance and bilateral coordination (Gallahue & Donnelly, 2003). Balance is the ability of a human to maintain his or her equilibrium in relation to the force of gravity, whether the body is static or performing a dynamic activity, as well as the ability to make very small alterations in the body when placed in various positions (Gallahue & Donnelly, 2003). To be able to maintain balance, the line of gravity that passes through the centre of gravity must also lie within the base of support. If this line falls outside the base of support, a person cannot maintain balance and will fall unless compensatory movements are made (Gallahue &

Donnelly, 2003).

Balance involves motor control skills that are required for the maintenance of posture whilst standing, walking or other common tasks, such as reaching for an object on a shelf (Bruininks & Bruininks, 2005). Both static (stationary) and dynamic (in motion) balance are in play (Gallahue & Donnelly, 2003; Bruininks & Bruininks, 2005). It is evident that all movement involves an element of balance, whether static or dynamic, as balance is a basic aspect of all movement. Due to this, it is critical that children develop their ability to balance from an early age (Gallahue & Donnelly, 2003).

Bilateral coordination is the ability to use both arms and/or legs together in a coordinated manner and is also known as bilateral integration (Le Roux, 2011; Pienaar, 2012). It is vital to develop bilateral coordination as it provides the foundation for the establishment of hand dominance and it is used in various daily tasks in the school and home environment (Le Roux, 2011; Pienaar, 2012). These skills begin to emerge during the early baby years and consist of symmetrical and asymmetrical movements (Le Roux, 2011). Symmetrical movements occur when both arms and legs are moved together. Examples may include jumping, clapping hands, rolling out dough or pastry with a rolling pin or when pushing a large object such as a piece of furniture (Le Roux, 2011; Pienaar, 2012). This type of coordination involves tasks that require body control, as well as simultaneous and sequential coordination of the upper and lower limbs. Bilateral coordination plays an important role in the participation of various sport and recreational games (Bruininks & Bruininks, 2005).

As soon as a child experiences problems, remedial action should follow immediately (Kapp, 1991**)**. Researchers suggest that motor skills proficiency in children can be improved through physical activity intervention programmes (Folio & Fewell, 2000; Morgan *et al.*, 2013). According to Hardy *et al*. (2010), the mastery of motor skills is sub-standard in most primary school children, indicating the importance of the need for early intervention programmes in the school environment. In this study, a motor skill development programme was designed to improve balance and bilateral coordination in children between 9 and 12 years old.

PURPOSE OF THE STUDY

The main purpose of the study was to design an appropriate motor skills development programme that could be implemented in any primary school to improve the balance and bilateral coordination of children aged 9 to 12 years.

METHODOLOGY

Research design

A quasi-experimental design was accordingly chosen for the current study (Gravetter & Forzano, 2003), as the research population already belonged to existing groups [Grade 5 classes] (Baumgartner *et al.*, 2002). A pre- and post-test design was used for both an experimental and a control group.

Subjects

One Quintile 2 school from a previously disadvantaged community in the Stellenbosch region was selected through a sample of convenience due to the proximity of the school. The study sample consisted of children (N=67; 30 girls, 37 boys) between the ages of 9 and 12 years old. From this sample, two classes in the school were recruited and thereafter randomly assigned by means of a numbering system, as either the experimental (n=35) or control (n=32) group. Only the experimental group participated in the 12-week motor skills development programme.

Ethical approval

The Research Ethical Committee of Stellenbosch University approved the research proposal (HS764/2012). Informed consent from the parents and assent from the children were obtained. The research proposal was submitted to the Western Cape Education Department (WCED) who granted permission to conduct this study in the selected school. Permission to conduct this study was also requested from and approved by the principal and teachers at the school.

Testing procedures

During the pre- and post-tests, both groups completed the Short Form, as well as the balance and bilateral coordination subtest activities in the Long Form of the Bruininks-Oseretsky Test of Motor Proficiency-2 (BOT-2) (Bruininks & Bruininks, 2005). The reason for completing the Long Form for the balance and bilateral coordination subtests was to gain additional information as the study focussed on these skills. This motor proficiency test battery has been used extensively in school environments (Plimpton & Regimbal, 1992; Hay & Missiuna, 1998; Reeves *et al*., 1999; Nourbakhsh, 2006; Wrotniak *et al*., 2006; Venetsanou *et al*., 2007; Faught *et al*., 2008; Venetsanou *et al*., 2009). Its use is recommended where a brief screening of motor proficiency is required (Bruininks & Bruininks, 2005; Deitz *et al*., 2007).

Motor Proficiency test

The BOT-2 is one of the most popular standardised motor skill test batteries used to determine the level of motor abilities or overall motor proficiency in children and young adults (Burton & Miller, 1998). The BOT-2 is a useful tool to a wide variety of practitioners, specialists and researchers in different settings. Some of the important uses of the BOT-2 includes: supporting the diagnoses of motor impairments; serving as a screening device to identify those who might have motor ability deficits and may benefit from further testing; making educational placement decisions (for example, placement into specific and/or adapted physical education [PE] programmes); developing and evaluating motor training programmes; and also assisting clinicians and researchers in assessments (Burton & Miller, 1998; Bruininks & Bruininks, 2005; Deitz *et al*., 2007).

The BOT-2 uses a composite structure that differentiates motor skills according to the limbs and muscles involved during movement, as well as according to the relationship to functional activities in the areas of postural control, locomotion and object manipulation. Both the Long and Short Form of the BOT-2 comprise of 4 motor area composites: fine manual control; manual coordination; body coordination; and strength and agility (Bruininks & Bruininks, 2005). The four BOT-2 motor area composites are further divided into 8 subtests including: fine motor precision; fine motor integration; manual dexterity; upper-limb coordination; bilateral coordination; balance; running speed; and agility and strength (Bruininks & Bruininks, 2005).

The Short Form consists of 14 items in total that are carefully selected to ensure a sufficient representation of all 8 BOT-2 subtests, to cover the widest range of ability and to produce reliable scores (Bruininks & Bruininks, 2005). This test has an internal consistency of ≥0.80, an inter-rater reliability of >0.90 and a test-retest reliability of ≥0.80 (Deitz *et al.*, 2007). Construct validity of this test is also good, r= 0.78 (Cools *et al*., 2009). The Short Form of the BOT-2 is a quick and easy to administer screening tool and provides a single score of motor proficiency, similar to the Total Motor Composite (TMC). The TMC is the most reliable and also the preferred measure when determining and describing overall motor proficiency. It is computed by calculating the sum of the 4 motor-area composite standard scores, when using the Long Form of the BOT-2 (Bruininks & Bruininks, 2005).

Motor skills intervention programme

A motor skills intervention programme was compiled by the researchers for children between the ages of 9 and 12 year old. The focus of this programme was to improve balance and bilateral coordination, which are needed to maintain a healthy and active lifestyle. Bilateral coordination plays an important role in playing various sport and recreational games (Bruininks & Bruininks, 2005). Information from skills development literature (Cheatum & Hammond, 2000; Bruininks & Bruininks, 2005; Dinoffer, 2011; Le Roux, 2011), was taken into account in the selection of suitable content for the programme.

The researchers, of which one researcher is a qualified and experienced Kinderkineticist, implemented the motor skill development programme whilst the Grade 5 Physical Education teacher assisted with discipline when available and where necessary. The nature of this programme may help empower the teachers to individually implement each lesson and further improve the FMS of the children after the conclusion of this study. The programme was presented during the second and third school terms for 12 weeks. The required 90 minutes (DBE, 2011) of PE time was divided into 3 lessons per week of 30 minutes each. Two lessons of 30 minutes each was allowed for the implementation of the motor skills development programme. The skill focus was alternated weekly between balance and bilateral coordination. The two lessons within each week thus had the same skill focus.

During the first lesson of each week, the researchers introduced and taught activities to children and allowed them time to practise each activity as far as the allocated PE time allowed. The second and third lessons of each week used the same activities as taught during the first lesson, but with added progression for each activity to develop the relevant motor skill further. Activities included dynamic balance (for example, perform 10 jumps with heel- to-toe foot placement); static balance (on dominant leg, lift non-dominant leg and place opposite arm under the lifted leg and pinch the nose); dynamic and static balance (walk on tippy toes on rope while balancing bean bag on the head, turn back and throw bean bag in basket while standing on the dominant leg); and bilateral coordination (jump with 2 feet together, inside the ladder and back out [zigzag pattern]).

This motor skills intervention programme also had to be adapted to include the specific elements, such as rhythmic movements and target games. These elements are required to be covered during PE lessons according to the South African Curriculum and Assessment Policy Statement (DBE, 2011).

Statistical analysis

The data was statistically analysed by the Centre for Statistical Consultation at Stellenbosch University. The results are presented as means and standard deviations. A 5% significance level ($p<0.05$) was chosen for significant results, but in some instances trends are reported for results that were not statistically significant. However, no claims are made on the validity of these trends, which typically need to be investigated further in follow-up studies.

A 3-way mixed model analysis of variance was done with time, gender and group as the fixed effects and the participants nested in group*gender as the random effect. The third order interaction effect (time*group*gender) was investigated to determine if gender in any way affected the results and, thereafter, the time*group second order interaction effect was investigated to determine if the intervention for the experimental group showed an effect when compared to the control group. Normal probability plots were investigated to check the normality of the data and were found to be acceptable.

DISCUSSION OF RESULTS

Long form

No significant differences were found for the mean balance score within the experimental ($p=0.09$) or the control group ($p=0.67$) or the pre- ($p=0.93$) and post-tests ($p=0.32$), for between group comparisons (Table 1 and Figure 1). There was no significant balance improvement in the experimental group, however, a strong trend toward improvement was observed in the mean balance score between the pre- and post-test of the experimental group ($p=0.09$). This indicates that a change occurred within the experimental group that did not occur in the control group, possibly due to participation in the motor skills intervention programme.

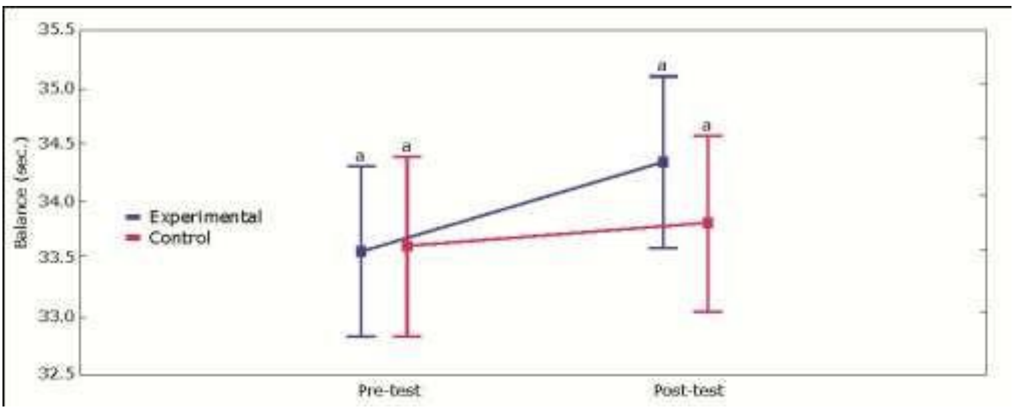
No previous comparable studies, emulating the exact research characteristics of the current study could be found. Similar studies have been conducted but using different populations and different modes or duration of intervention. Gupta *et al*. (2011) also found increased balance performance, within their experimental group, and almost no change in their control group after a 6-week strength and balance training programme for children with Down‟s syndrome.

Connolly *et al*. (1993) conducted a longitudinal study on the effects of an early intervention programme on Down‟s syndrome children and found further increased balance performance during the third follow-up test. There was, however, no control group to whom the early intervention group could be compared. Lewis and Fragala-Pinkham (2005) also reported improved balance, in the absence of a control group, after a 6-week aerobic conditioning and strength training intervention programme on a Down‟s syndrome girl. As a pedagogical model for improving balance/bilateral coordination and eye-hand coordination in school learners, the MUGI model (*Motorisk Utvecklingsom Grund för Inlärning*), for motor skills training was also found to be useful. Furthermore, daily physical activity and motor training showed positive effects in the latter study (Ericsson, 2013).

TABLE 1. **MEAN BALANCE SCORES FOR EXPERIMENTAL AND CONTROL GROUP OVER TIME**

Group	**Pre-Test Mean±SD**	**Post-Test Mean±SD**	**p#**	**Mean diff. (Pre - Post)**
Experimental	11.11±0.66	11.40±0.66	0.09	-0.78
Control	10.96±0.69	11.24±0.69	0.67	-0.20
p+	0.93	0.32	-	-

SD= Standard deviation
p+ Differences between groups for the pre- and post-test
p# Differences within groups from pre-to post-test
Mean differences within groups from pre- to post-test



(a-a) No significant differences (p>0.05)

FIGURE 1. **BALANCE (Long From): DIFFERENCE BETWEEN EXPERIMENTAL AND CONTROL GROUP FROM PRE- TO POST-TEST**

According to the mean differences between groups, the experimental group improved their balance during the post-test by approximately 0.58 seconds more than the control group. This increase may be due to participation in balance activities addressed in the 12-week motor skills intervention programme. Van Niekerk *et al*. (2007) similarly found significant improvement in the experimental group‟s balance after a 10-week intervention programme amongst South African shelter-dwelling children. Their control group showed no significant improvements.

Alphabet letters are used in the next figures to indicate a significant difference (p<0.05) between and/or within the experimental and control groups. If there are any overlapping letters (a-a)/(ab-a)/(a-ab)/(ab-b)/(b-ab)/(ab-ac)/(ab-ab)/(c-ac)/(ac-ac)/(cb-ab)/(ac-a)/(c-ac)/(ac- ac), it indicates that there was no statistically significant difference. Where the letters are completely different, (a-b)/(b-a)/(cb-a), it indicates a statistically significant difference between and/or within the experimental and control groups.

Bilateral coordination

Bilateral coordination means, standard deviations and mean differences for the entire duration of the study are summarised in Table 2.

TABLE 2. **BILATERAL COORDINATION (Long Form): MEANS, STANDARD DEVIATIONS AND MEAN DIFFERENCES FOR EXPERIMENTAL AND CONTROL GROUP BETWEEN PRE- AND POST-TESTS**

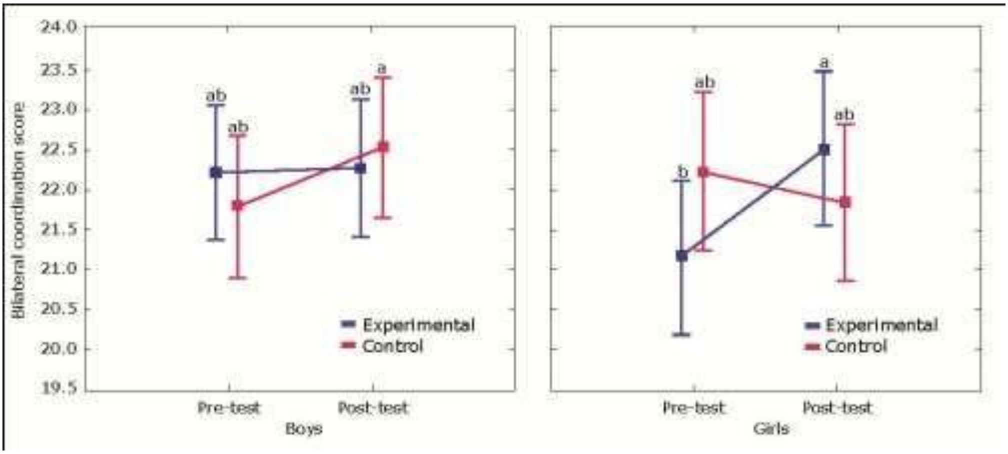
Group	**Pre-Test Mean±SD**	**Post-Test Mean±SD**	**p#**	**Mean diff. (Pre - Post)**
Experimental	21.47±2.03	22.32±1.57	0.04*	-0.69
Control	21.94±1.72	22.18±1.99	0.61	-0.17
p+	0.49	0.64	-	-

p+ Differences *between* groups for the pre- and post-test p# Differences *within* groups from pre-to post-test Mean differences *within* groups from pre- to post-test
* Significant difference (p<0.05) (Pre vs. Post)

A significant difference was found for the mean bilateral coordination score between the pre- and post-test of the experimental group (p=0.04) (Table 2). No significant difference was found for the mean bilateral coordination score between the pre- and post-test of the control group (p=0.61). A significant change was observed only within the experimental group, which may be ascribed to the bilateral coordination activities that were performed during the 12-week motor skills intervention programme. In addition, no significant differences were found for the mean bilateral coordination score between the experimental and control groups at pre- (p=0.49) and post-testing (p=0.64). The significant difference found within the experimental group is not supported, however, by the interaction p-values between groups. Thus, according to the mean differences between the groups, the experimental group improved their bilateral coordination score by 0.52 (touches, jumping jacks, jumps, pivots, and taps combined), more than the control group (Table 2).

Connolly *et al*. (1993) found further improved bilateral coordination performance during their third follow-up test during the longitudinal study on the effects of an early intervention programme on Down syndrome children. There was, however, no control group for comparison. According to Lewis and Fragala-Pinkham (2005), bilateral coordination of a Down‟s syndrome girl improved after a 6-week aerobic conditioning and strength training intervention programme. Van Niekerk *et al*. (2007) reported a significant improvement in the bilateral coordination of the experimental group after a 10-week intervention programme

involving South African shelter-dwelling children. The control group showed no significant improvement. In a study done by Ericsson (2008) with 251 Swedish children, it was found that balance/bilateral coordination of both boys and girls improved with extended physical activity (5 PE lessons per week), and additional motor training (a 45-minute session per week), and the difference between them decreased with the extended training sessions.



(a-b)/(b-a) Significant difference ($p<0.05$) Pre vs. Post
(ab-a)/(a-ab) No significant difference ($p>0.05$) Pre vs. Post and/or Exp vs. Ctrl (ab-b)/(b-ab) No significant difference ($p>0.05$) Exp vs. Ctrl
(ab-ab) No significant difference ($p>0.05$) Pre vs. Post and/or Exp vs. Ctrl

FIGURE 2. **BILATERAL COORDINATION (Long Form): GENDER DIFFERENCES**

As seen in Figure 2, no significant differences were found in the mean bilateral coordination scores according to gender at the commencement of this study. However, when investigating the third order interaction (time*group*gender), a significant difference was found for gender (p=0.01). Thus, gender appeared to play a significant role in the improvement of bilateral coordination. A trend towards approaching significance was found between the boys and girls of the experimental group at the pre-test (p=0.09). This may be explained by the observation that the girls in the experimental group began this study with a relatively lower mean bilateral coordination score when compared to the boys at pre-test. This trend, however, disappeared after participating in the 12-week motor skills intervention programme (p=0.74). Thus, the girls in the experimental group seem to have improved their bilateral coordination to a similar level as that of the boys after performing the bilateral coordination activities in the motor skills intervention programme.

When investigating the performance of the boys, no significant differences were found for the mean bilateral coordination score within the experimental (p=0.90) and control groups (p=0.11), or between the pre- (p=0.48) and post-tests (p=0.67) (Figure 3). A greater increase in the bilateral coordination of boys was also observed within the control group (p=0.11), whereas the experimental group presented almost no change (p=0.90). The change in the control group may be due to the fact that the control group began the study with a lower mean bilateral coordination score and may have improved as a result of maturation.

It appears that the improvement in bilateral coordination was greater amongst girls when compared to boys (Figure 2). Accordingly, when investigating the mean bilateral coordination scores of girls, a significant difference was observed between the pre- and post- test of the experimental group (p=0.01). A trend towards significance was observed for the mean bilateral coordination score between the girls of the experimental and control groups at the pre-test (p=0.13). However, the score decreased after completion of the post-test. This is supported by the significant increase found within the experimental group (p=0.04) and the mean bilateral coordination scores of the control group remaining relatively similar (p=0.45).

Balance and bilateral coordination

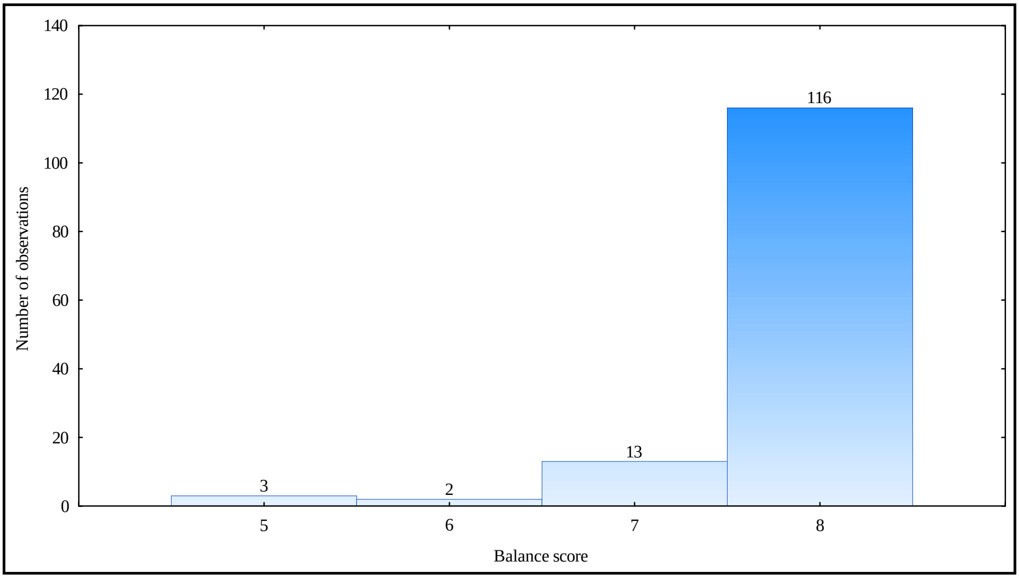


FIGURE 3. **BALANCE ACTIVITIES: NUMBER OF OBSERVATIONS**

The scores for the experimental and control groups as well as the scores achieved on both the Short Form balance and bilateral coordination activities are presented in Figure 3 and Figure 4 respectively. It is evident that there was very little variation in the scores achieved during the 2 balance and 2 bilateral coordination activities used in the Short Form of the BOT-2. Most children (86.57%) achieved the maximum scores possible. Thus, no further statistical analyses were conducted between groups or between pre- and post-tests and no significant differences were found (p>0.05). Bruininks and Bruininks (2005) state that due to the developmental nature of some BOT-2 subtests, these subtests produce little variability in the performance for some age groups. Thus, this may have been the case for balance and bilateral coordination in the current study. Wuang and Su (2009) found a similar occurrence for the balance subtest during their study with intellectually impaired children. They found that most of the items on the balance subtest were too easy for the sample as more than half of the group achieved the maximum scores.

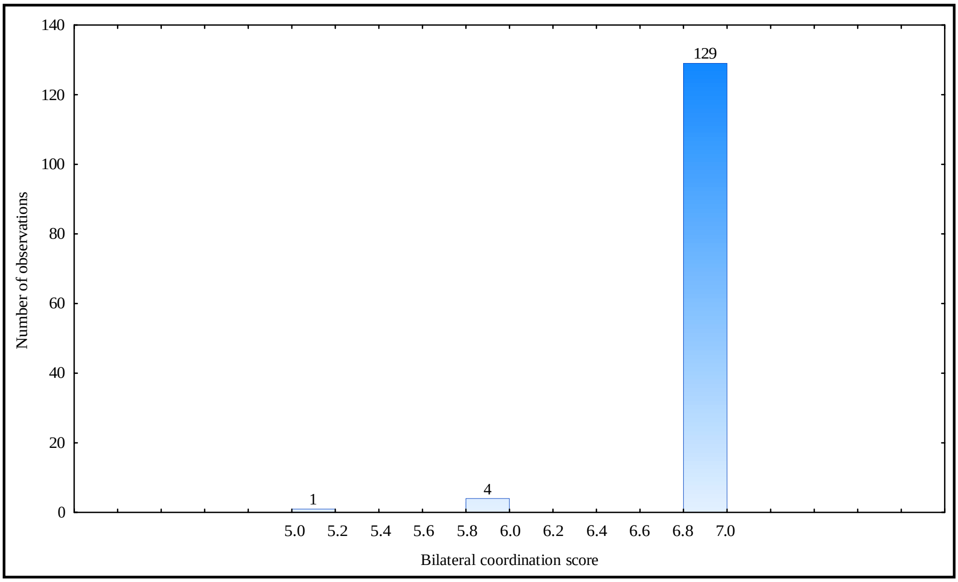


FIGURE 4. **BILATERAL COORDINATION ACTIVITIES (Short Form): NUMBER OF OBSERVATIONS**

The fact that almost all participants were able to achieve the maximum score may indicate that these activities were too easy and may not be suitable for measuring balance and/or bilateral coordination efficiently. Therefore, using these Short Form activities of the BOT-2 as the only evaluation of balance and bilateral coordination may limit the ability to investigate the true effect that the motor skills intervention programme had on these motor skills. Gupta *et al*. (2011) found similar results regarding balance and described no variation between the pre- and post-tests or between the two sample groups due to a ceiling effect where the median score achieved during the pre-test already was the maximum score. Therefore, no significant improvement in balance was observed at the post-test after completion of the motor skills development programme.

Balance and bilateral coordination play an important role in the physical activity participation of children. According to the literature, children should have mastered the basic motor skills by the age of 7 years (Gallahue & Donnelly, 2003). Yet, as seen in this study, children between the ages of 9 and 12 years still struggle to perform some of the most basic balance and bilateral coordination tasks, such as skipping or balancing on one leg. This suggests that the children of today are struggling to master motor skills during the relevant windows of opportunity resulting in experience delays in motor skill proficiency, subsequently affecting their participation in physical activity.

CONCLUSIONS

Improvements in balance and bilateral coordination were observed in the experimental group after completion of the 12-week motor skills intervention programme. The improvement in

balance was not significant, yet presented a strong trend towards improvement when compared to the control group. These changes in the experimental group suggest that the motor skills development programme may have played a role in the improvement of balance. Gupta *et al*. (2011) found similar results after implementing a six-week strength and balance training programme.

A significant improvement was seen in the bilateral coordination of the experimental group, especially amongst the girls, when compared to the control group. This improvement may be ascribed to participation in the motor skills intervention programme. Similarly, Van Niekerk *et al*. (2007) found corresponding results after implementing a 10-week intervention programme. Kaur (2013) studied the effects of robot-child-interactions on the bilateral coordination skills of typically developing children aged between four and 11 years in a six- week intervention program. The post-test results indicated that the experimental group improved their bilateral coordination skills (Kaur, 2013).

Therefore, reiterating the words of Logan *et al*. (2011), early childhood education centres, especially pre- and primary schools, should implement planned movement programmes, such as the 12-week motor skills development programme implemented during the current study, as a strategy to promote FMS development in children. These programmes may be beneficial to all primary school children, including those with possible movement difficulties, especially from previously disadvantaged schools.

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CORRELATION BETWEEN PASSIVE AND DYNAMIC RANGE OF ROTATION IN LEAD AND TRAIL HIPS DURING A GOLF SWING

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ABSTRACT

The aim of this pilot study was to determine the association between the passive range of motion versus golf dynamic rotation range of both the lead hip and trail hip of healthy adult male golf players. Seven skilled male golfers between the ages of 18 and 40 years were selected randomly. Passive hip rotation range of movement (ROM) measurements were collected with a hand-held inclinometer. Dynamic kinematic hip rotation data were captured with a high-speed opto-electric 3-D motion capture system during a golf swing. There was a positive correlation (r= 0.42) between the passive hip ROM and dynamic hip range of movement during the golf swing of the lead hip, but the correlation was not significant (p= 0.34). There was a weak negative correlation (r=-0.05) that was not significant (p= 0.9) between the passive hip range of movement and dynamic hip range during the golf swing of the trail hip. Clinicians and coaches should thus note that improving passive hip ROM might not be associated with an increased hip rotation utilised during the golf swing.

Key words: Lower limb rotation; Golf swing biomechanics; Hip kinematics; Lower back pain.

INTRODUCTION

The golf swing involves a sequence of complex multi-segmental movements (Keogh & Hume, 2012). This smooth and well-timed, sequence of body movements mainly occurs in the transverse plane (Cabri *et al*., 2009). The golf swings commences from the address posture, the starting position when the golfer faces the ball. The typical golf swing is executed in three main phases, backswing, downswing and the follow-through phase. In order to propel the ball forward towards the target, the golf swing requires powerful movement of the spine, shoulders and hips (Keogh & Hume, 2012).

The hip joint acts as the main driver during the golf swing because it initiates the movement from the address posture (Hume *et al*., 2005; Healy *et al*., 2011). As the swing continues, hip rotation precedes movement of the arms and spine. The hips continue to rotate until the end of the follow through phase (Keogh & Hume 2012). The hip joint also acts as a pivot between the upper and lower body segments to facilitate synchronised movements during the golf swing. Therefore, appropriate hip movement is critical for successful execution of the golf swing.

Inadequate hip rotation may be associated with golf related back pain. Back pain affects one in three golfers (Murray *et al*., 2009). It is postulated that reduced passive hip rotation place increased and repetitive strain on the lower back structures, which eventually leads to pain (Murray *et al*., 2009; Gulgin, 2012). Murray *et al*. (2009) illustrated that golfers with back pain have reduced passive and active lead hip (LH) internal rotation (IR), compared to golfers without back pain. Asymmetrical total hip rotation range, between the lead and trail hips, is also associated with back pain (Gulgin, 2005; Van Dillen *et al*., 2008). Sportspersons who regularly partake in a sport that requires repetitive rotation between the trunk and pelvis have also been shown to have limited LH total range of hip rotation compared to that of the trail hip (TH) (Van Dillen *et al*., 2008). Reduced total range of hip movement may thus predispose golfers to overuse problems, such as back pain, although the optimal hip range during the golf swing remains unknown.

Clinically, non-weight bearing total passive and active hip range of motion is utilised to estimate whether a golfer has adequate hip range for proper execution of the golf swing. Traditional methods to measure hip range in sitting, supine or prone positions are reliable. However, to date it is unknown whether this clinical method for measuring hip range is also a valid assessment of the amount of rotation required during the actual golf swing. In addition, it is uncertain whether passive hip rotation range is correlated with the amount of hip rotation used during the golf swing. Such knowledge will assist coaches and clinicians to optimise rehabilitation programmes post injury or to enhance performance.

PURPOSE OF STUDY

To our knowledge, there is no information about the correlation between clinical hip rotation assessments and the amount of hip rotation utilised by a golfer during a golf swing. The main aim of this pilot study was to determine the association between the total passive range of motion (ROM) and golf dynamic rotation ROM of both the lead hip (LH) and trail hip (TH) during the golf swing in healthy adult male golf players. In addition, the proportion of hip passive range utilised during the golf swing was determined. This study also provides preliminary data and feasibility information for similar larger studies in this field.

METHODOLOGY

Study design

A descriptive study was conducted. A preliminary, reliability study was conducted to ascertain the reliability of using an inclinometer to measure passive hip rotation movement.

Sample recruitment, size and description

An acquired candidate list form from the Western Cape (WC) region of golf academies and clubs was randomised. Candidates from the list were contacted telephonically in a descending order. Whilst answering the first section of the questionnaire telephonically, eligibility was established. A sample size of 7 participants was recruited for this pilot. Resources and the exploratory nature of the pilot study limited the sample size. A sample size calculation was not possible due to non-existence of similar studies or pilot data on which a sample size calculation can be based.

Male golfers aged between 18 and 40 years with normal waist-hip ration (WHR) and a handicap of 16 or lower were eligible to participate. Participants had to have played golf for at least 2 years, and play an 18 hole-round of golf per week and continue practising 3 or more hours per week on the golf range or greens. Candidates were excluded if any musculo-skeletal injury, pain, surgery or fractures to the spine, upper or lower extremities were present. Participants with hip abduction ROM less than a normal 30° and hip flexion less than a normal 105° were also excluded. None of the participants had abnormal hip ROM, based on clinical passive ROM assessment.

Ethical clearance

The study received approval from the Health Research Ethic Committee at Stellenbosch

University (no. S12/11/272). Informed consent was obtained from each participant.

Instrumentation

Total passive hip rotation range of motion

Total passive hip rotation range of motion was measured with a plastic Baseline® Bubble hand-held inclinometer. The inclinometer reliability was better than that of a digital inclinometer or goniometer (Bierma-Zeinstra *et al.*, 1998). A hand-held inclinometer is user- friendly for clinical utility. The validity and reliability of a hand-held inclinometer were found to be excellent while measuring passive hip ROM (Boyd, 2012).

Total dynamic hip rotation range of motion

Total dynamic hip rotation range of motion during a golf swing was measured using an 8 camera T-10 Vicon (Ltd) (Oxford, UK) system with integrated software, Nexus 1.8. The Vicon motion analysis system is a 3-dimensional (3-D) opto-electrical motion capture system, which is widely used in a variety of ergonomics and human factor applications. The 3-D motion analysis technology is regarded as the gold standard for 3-D analysis of movement due to the good reliability and validity and measurement errors of less than 2º in the transverse plane (Kadaba *et al.*, 1990; Tsushima *et al.*, 2003).

Preliminary reliability study

A preliminary study was completed to determine the investigator intra-rater reliability for total inclinometer passive hip articular range measurements. Eight golfers, aged 17 to 35 years, who met the inclusion criteria of the study, participated in the reliability study. Measurements were taken at the end of a practice day. Prior to the measuring procedure, each participant performed 2 supervised hip rotation stretches (a standing stork stretch and standing sit-squat stretch), chosen to enhance the surrounding soft tissue for hip flexibility (Tamai *et al.*, 1989; Evans *et al.*, 2005; Kurihashi *et al.*, 2006). Seated measurement positions, were done as described in a later section. Three measurements of the total passive range of each hip (LH, TH) were measured 2 minutes apart in each participant. The hip joint was returned to neutral before the following ROM was recorded.

Procedures

Questionnaire and data collection sheet

After eligibility was obtained telephonically, the data sheet of the following sections in the questionnaire was completed during an interview prior to the passive procedures. The questionnaire included questions regarding the participant's personal details and demographics, as well as their medical, golf, family, physical conditioning and sport participatory history. The study was conducted in the Biomechanical Laboratory at Stellenbosch University. Participants were familiarised with the laboratory environment and equipment, and then debriefed regarding the testing procedure.

Passive hip rotation range of motion measured in sitting

Participants were dressed in knee-exposing, non-restrictive clothing without shoes. Prior to the passive range of movement assessment, a 10-minute stationary bicycle warm-up was completed. Participants sat on the firm medical plinth, set at an 85cm height. A 45° angled plastic-covered wedge was added as back support and a pelvic belt was placed over the anterior iliac spine and strapped to the plinth to prevent any pelvic movement during passive hip rotation (Figure 1). The contra-lateral foot was placed on the plinth, leaving the hip in full flexion, thereby stabilising the hip and pelvis, which was being measured. The thigh of the measured hip was positioned on the plinth and measured at a 135° hip-trunk angle (leaning backwards position), to replicate the hip's position during the address position (Hume *et al*., 2005). The fibular head was marked with a skin marker, as this point was used for the inclinometer placement (Figure 2).

FIGURE 1. **SEATED POSITION FOR INCLINOMETER HIP ROTATION MEASUREMENTS**

FIGURE 2. **INCLINOMETER PLACEMENT FOR HIP ROTATION MEASUREMENTS**

The investigator sat on a 25cm high gym step in front of the participant, facing the knee at eye height level. Total hip rotation was performed passively from a firm end-feel at the top of the one end of the range was felt until the same firm end feel was felt at the other end of the range, or any pelvic compensatory movement was noted. The hip was returned to the mid- position before external rotation and then internal rotation was recorded separately. Each of the 3 movements was performed in the same order for each participant.

Anthropometric measurements

Anthropometric measurements were recorded as required for a VICON-analysis. The participant's stature, mass, leg length, shoulder offset, hip circumference, hand thickness, as well as the width of the wrist, elbow, knee and ankle were recorded using an anthropometer and digital scale.

Dynamic hip rotation range of motion measured during a golf swing

All reflecting clothing or objects were either removed or covered to prevent interference with the opto-electric 3-D motion capture-system. A lower limb retro-reflective marker set was placed on bony landmarks by a physiotherapist experienced in marker placement and who had training for this according to the conventions of the Plug-in-Gait, lower limb model (Figure 3). System calibration was achieved according to standard VICON procedures. Model calibration was captured with the participants assuming a standard standing T-position. Soft golf balls were used for ball-impact for the purpose of protecting the laboratory equipment. Each participant used his own 7 iron and golf shoes. Five to 10 practise swings were allowed prior to the testing procedure. A series of 10 swing-trials were performed for data collection purposes. Verbal instructions (Table 1) were given to each participant prior to each of the 10 captured golf swings. The total range of hip rotation was calculated using the Plug-in-Gait model and filtered with a 4^{th}-order Butterworth filter at a 10Hz cut-off frequency.

TABLE 1. **GOLF SWING INSTRUCTION TO PARTICIPANTS**

Description of swing movement	**Instructions**
Face down the line holding their own 7-iron club; each subject wearing his own golf shoes	"Address your ball in the manner most common to the start of your swing."
Three golf swings (full back swing to full final phase) was practised to instil a normal practice swing while the soft ball was in place	"Take a few practise swings to familiarise yourself with the lab environment and get a feel for the soft ball."
A full swing was captured 10 times (from address to finish phase). The Bio-statistician provided a starting nod for each participant	"Get ready to take a full swing, aim for the centre of the wall at the back of the lab."
Encourage the participants to walk away and re-address the ball each time he swings ensuring the most natural swing he could mimic in the lab set-up.	"Relax, and walk away from the starting point, take care not to bump any equipment please." "Repeat the swing again." (until 10 trails is reached)

FIGURE 3. **LOWER BODY RETRO-REFLECTOR MARKER**

PLACEMENTS: ANTERIOR, LATERAL AND POSTERIOR VIEWS

Data analysis

The outcomes were passive hip ROM during a seat-adjusted position and dynamic hip ROM measurement during a golf swing. Microsoft Excel and STATISTICA version 10 were used to analyse the data. To determine inclinometer intra-rater reliability, a 2-way Interclass Correlation Coefficient (ICC), standard error of measurement (SEM) and a 95% confidence interval level was calculated. ICC values of between 0.85 and 1.0 were considered good reliability. For the descriptive statistics, the mean was used as a measure of central location and standard deviations as indicators of variability. Spearman correlation coefficients (r) were calculated and scatter plots were used to express the correlation between total passive ROM and total dynamic ROM. T-tests were used to test for difference between the lead and trail passive hip ROM, as well as between the dynamic hip ROM of the lead and trail hip. A probability value of $p<0.05$ was set for the statistical significance for all tests.

RESULTS

Participant demographics

TABLE 2. **PARTICIPANT DEMOGRAPHICS**

Variables	Mean±SD
Age (years)	26.5±8.1
Height (cm)	176.9±5.1
Mass (kg)	79.1±13.5
HRT/7	13.2±5.9
HC	1.0±1.0
WHR	0.9±0.9

HRT/7= hours training per week HC= Handy-cap system WHR= Waist-hip-ratio

The descriptive data of the participants (N= 7) is summarised in Table 2. All participants were right-handed players. The mean age at which the participants started playing golf was 9.7±4.1 years. None of the participants had upper limb, lower limb or musculo-skeletal complaints of the spine in the past 12 months. The WHR measurements were within normal limits (0.9±0.06).

Reliability of passive ROM measurements

The ICC for passive ROM was 0.81 (95% CI: 0.46-0.96) and the SEM was 3.02 for the intra- rater reliability.

Passive hip ROM

TABLE 3. **LEAD AND TRAIL HIP: MEAN PASSIVE AND DYNAMIC ROM IN DEGREES AND PERCENTAGE UTILISED**

	Passive ROM°	Dynamic ROM°	*Difference°	% Utilised
Lead hip				
P1	60.0	30.9	29.1	51.5%
P2	55.0	27.2	27.8	49.5%
P3	70.0	36.5	33.5	52.1%
P4	65.0	36.7	28.3	56.4%
P5	70.0	29.5	40.5	42.1%
P6	55.0	19.9	35.1	36.2%
P7	60.0	22.3	37.7	37.2%
Mean±SD	62.1±6.4	29.0±6.5	33.1±5.0	46.4±8
Trail hip				
P1	60.0	43.6	16.4	72.7%
P2	66.0	23.5	42.5	35.6%
P3	60.0	35.2	24.8	58.7%
P4	64.0	43.1	20.9	67.3%
P5	60.0	43.1	16.9	71.8%
P6	65.0	33.4	31.6	51.4%
P7	55.0	29.6	25.4	53.8%
Mean±SD	61.4±3.8	35.9±7.8	25.5±9.2	58.8±13

P= Participant *Difference between total passive range and dynamic range during swing °= Degrees

Passive hip ROM of the lead and trail hip

There was no significant difference between the lead and trail passive hip ROM ($p=0.8$) (Table 3). Four of the participants had a passive ROM asymmetry of 10 degrees or more between the 2 hips.

Dynamic hip ROM during the golf swing of the lead and trail hip

There was a statistically significant difference ($p=0.04$) between the dynamic hip ROM of the lead and trail hip (Table 3). Three of the participants demonstrated a dynamic hip ROM asymmetry of 10 degrees or more between the 2 hips during the golf swing.

Range difference between passive hip ROM and dynamic hip ROM during golf swing

A male golfer utilised 46.4% of the mean passive lead hip total ROM while in the trail hip, he utilised 58.8% (Table 3). The difference between passive hip ROM and dynamic hip ROM during the swing is reported in Table 3. The difference between the passive and dynamic hip ROM ranged between 27.7 to 40.5 in the lead hip and 16.4 to 42.5 in the trail hip (notably larger than the SEM). In the trail hip, a bigger variability was noted when the ROM difference was compared to the lead hip.

Correlation between passive hip ROM and dynamic hip ROM during golf swing

Lead hip: Correlation between passive hip ROM and dynamic hip ROM during golf swing

There was a positive correlation (r= 0.42), albeit insignificant (p=0.34), between the passive hip ROM and dynamic hip ROM during golf wing of the lead hip (Figure 4).

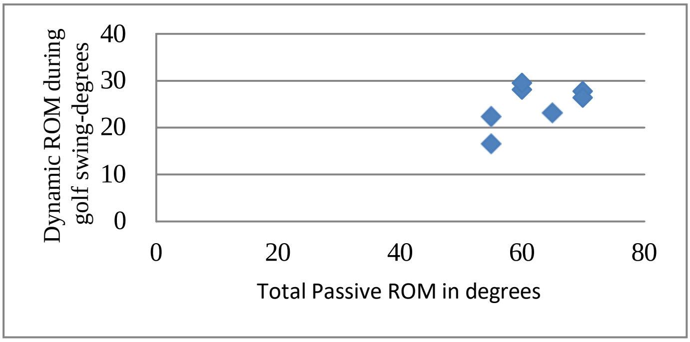

FIGURE 4. **LEAD HIP**

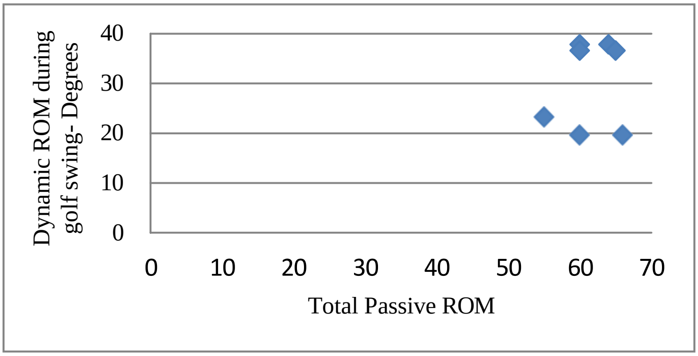

FIGURE 5. **TRAIL HIP**

Trail hip: Correlation between passive and dynamic hip ROM during golf swing

There was an insignificant (p=0.90) and weak negative correlation (r=-0.05) between the passive hip ROM and dynamic hip ROM during the golf swing of the trail hip (Figure 5).

Correlation between lead and trail hip passive hip ROM

There was an insignificant (p=0.19), moderate negative correlation (r=-0.55) between the lead and trail hip total passive ROM.

Correlation between lead and trail hip dynamic hip ROM during the golf swing

There was an insignificant (p=0.78) and weak positive correlation (r= 0.12) between the lead and trail hip total dynamic ROM during the golf swing.

Graphic illustration of the golf swing

The following graphics present an illustration of the kinematic pattern of the group mean as reported in the lead hip (Figure 6) and trail hip (Figure 7).

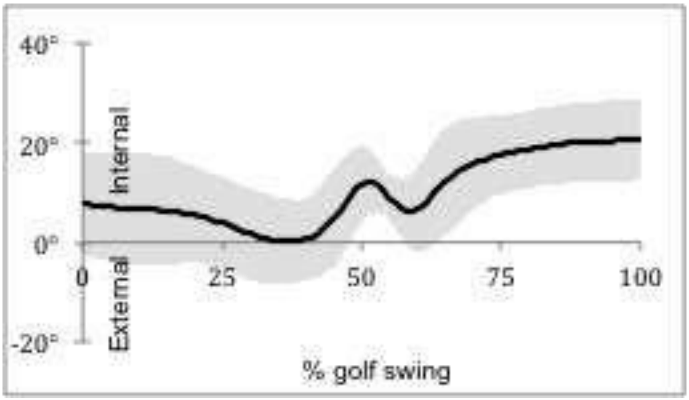

FIGURE 6. **LEAD HIP ROTATION DURING A SWING**

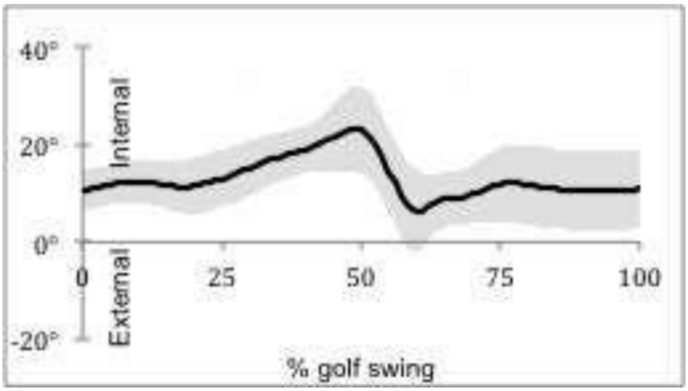

FIGURE 7. **TRAIL HIP ROTATION DURING A SWING**

DISCUSSION

This pilot study provides the first information on the correlation between passive hip ROM (a common clinical method for measuring hip range in golfers), and actual hip ROM during the golf swing.

Participant demographics

In the sample, the waist-hip ratio (WHR) was considered part of the participant eligibility criteria as it provides an indication of the body fat percentage. Participants with a high obesity index would have been excluded from this study sample, as it would have influenced the degree of hip rotation.

Kouyoumdjian *et al*. (2012) investigated the relationship between hip rotation and the WHR. WHR measures central adiposity in participants. A hip loses 0.98° of rotation ($p<0.0006$) for each fat percentage-unit that increases. Therefore, the WHR-method was considered as part of the participant eligibility criteria as it provides an indication of the body fat percentage. Participants with a high obesity index were excluded to assure sample homogeneity with respect to WHR.

Handicapping a golfer is an effective equalizer among golfers with different abilities. A golf handicap (HC) system (Table 4) is based on the assumption that in every 9- and 18-hole stroke played by a golf player, he/she will endeavour to achieve the best score at each hole played and will report this score to the South African Golf Association within a 24 hour period, regardless where the round of golf was played. The current sample has an average HC of 1 (±0.8), which illustrate that they play golf regularly.

TABLE 4. **PURPOSE OF HANDICAP (HC) SYSTEM**

- Provides all golfers with a fair HC;
- Reflects the player's inherent ability and trends to his recent score;
- Has the ability to adjust an HC to a player's ability;
- Disregards freak high scores that bear no relation to the player's normal ability;
- Establishes handicaps for all golfers, from informal play to championships;
- Assists a handicapper to identify a player whose handicap does not reflect playing ability.

The mean age for the study group was 26.6±8.2 years. Gosheger *et al*. (2003) reported in their study regarding injuries and overuse syndromes in golfers that the average age of golfers was 46 years, and most have been playing golf for approximately 10 years. Gosheger *et al*. (2003) studied a larger group of 703 golfers and, therefore, this age group may represent the population of golfers better than it may represent the participants in the sample of the current study.

Total passive hip ROM

Concurrent with the findings of the current study, excellent inclinometer reliability measurement in a study measuring hip flexion range during straight leg raising tests, the standard error of measurement was between 0.54 and 1.22 and the minimal detectable change was between 1.50 and 3.41 (Boyd, 2012). This author also reported a low variability and excellent validity for a hand-held inclinometer. This illustrates that the differences found between the passive hip ROM and dynamic ROM during the golf swing due to measurement error is not likely in the current study, as the differences were much larger than the measurement error.

In young male golfers, this was reported as 62.2±6.4 in the lead hip and 61.5±4.0 for the trail hip. Murray *et al*. (2009) reported the prone passive inclinometer hip range in golfers as 73° in the lead hip and 78° in the trail hip. The larger rotation range of ±15° could be explained by the fact that the reported ROM included males and females in the study group. It has been reported that female subjects, irrespective of age, had between 16 to26° more rotational mobility than their male counterparts did (Soucie *et al*., 2011). Due to this, a male-only population was included in the present study. Soucie *et al*. (2011) reported that female golfers' passive inclinometer hip ROM in a lead hip was 93.3±17 and in the trail hip it was 92±19. Both of these studies reported larger ranges than the male-only sample in the current study.

Regardless of gender or side, seated passive hip ROM in a normal non-golfing population was reported to be 78.5±11 (Kouyoumdjian *et al*., 2012) and 76.5 (Bierma-Zeinstra *et al*., 1998). These ranges fell well within the passive range measured for golfers in the current study. However, possible differences could be attributed to measurement techniques, joint positions or measuring instrumentation. A slight tightening of the strong and dense hip capsule could be expected to be reached in the seated hip extension (135° trunk-hip position) posture, as position towards full hip extension will tighten the joint capsule (Norkin, 1992).

Dynamic hip ROM during golf swing

In published reports, the angle measured between the hip axis (pelvis) and the shoulder axis is described sometimes as the amount of hip rotation taking place during a golf swing (Burden *et al*., 1998; Hume *et al*., 2005; Myers *et al*., 2008). This measurement of hip rotation represents pelvic rotation in relation to shoulder axial rotation. In the current study, femoral acetabular hip rotation during the golf swing using the VICON plug-in-gait model was measured.

The mean dynamic hip ROM in male golfers in the current study reported the lead hip rotation as 29±6.5 and the trail hip as 35.9±8 during a golf swing (Table 3). The active weight bearing hip range in a rotation-related sport, such as golf, occurs in a closed kinetic sequence. Gulgin *et al*. (2010) discovered that the weight-bearing rotation ROM measured was 64.5° in the lead hip and 23.8° in the trail hip range. These measurements were taken by a VICON system on a group of female golfers in a standing closed kinetic chain position. These results indicated that hip rotation ROM in a golfer adapts according to the imposing physiological demands.

In the current study, 2 of the golfers had less than the mean dynamic articular range in the lead hip than the group average, while two golfers reported 10 degrees more. Two of participants had less dynamic ROM in the trail hip than the group average, while three participants had 5 degrees more than the average (Table 3). This indicates variation in hip rotation among young golfers with similar profiles. All coaches and clinicians should thus consider individual variation.

Practical applications

The correlations between the passive hip range and dynamic hip range during the golf swing were not significant and produced weak correlation values. The interpretation of this finding is clinically significant for physiotherapist, biokineticists and sport trainers who engage in the rehabilitation and performance of golfers. The findings of the present study imply that passive hip ROM assessment may not be a valid indicator of the amount of hip rotation utilised during the golf swing. The before dynamic assessment of hip ROM is the optimal marker for establishing the amount of hip rotation utilised by a specific golfer. In addition, the findings suggest that simply improving passive hip ROM will not naturally translate into increased dynamic hip ROM during the golf swing. Many other factors, such as sensorimotor control and relative flexibility, may influence the amount of hip rotation utilised during the golf swing. These findings highlight the principle of specificity that should be applied in the rehabilitation or performance enhancement of the golf swing in golfers.

LIMITATIONS AND RECOMMENDATIONS

Although the results provide valuable information and insight into the relationship that exists between the passive and dynamic hip rotation, there are several limitations. A larger sample size is required in future studies. Sample size calculations can be conducted now based on the preliminary findings of this study. The inclinometer reliability study did not use a blinded measurer, and inter-tester reliability was not performed and should be considered for future studies. Due to limited resources, the hip joint integrity was not investigated (MRI, x-rays and sonars), but could be considered. Possible kinematic influences from the knee and foot were not assessed, but it could play a role in influencing the kinematic chain of the lower limb.

In addition to addressing the limitations as outlined, the influence that the hip joint flexibility has on hip mobility in a golfer would be of great clinical value. Comparing low handicap golfers to higher handicap golfers could be valuable in exploring the effect a golfer could expect on his lumbar spine after long periods of intense exposure to a rotation related sport. A normative database for dynamic hip rotation ROM in a golfer's hip joint should be established, which can assist in classifying the golfer according to their degree of rotation and subsequent risk of injury. Investigation into golfers with pathologies, injury or pain in the lower back should be conducted. This could provide insight into rotational factors associated with musculo-skeletal problems that golfers may experience.

CONCLUSION

This study provides preliminary information about the correlation between passive hip ROM and dynamic hip ROM during the golf swing. There were insignificant and weak correlations

between the passive hip range and dynamic hip range during the golf swing. Clinicians and coaches should thus note that improving passive hip ROM might not increase the amount of hip rotation during the golf swing. Future research should be conducted with larger samples.

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STRENGTH AND AGILITY SKILLS OF GRADE 1-LEARNERS: NORTH-WEST CHILD STUDY

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ABSTRACT

The aim of this study was firstly to determine the current profile of strength and agility skills of Grade 1-learners in the North-West Province and, secondly, to establish whether there was gender differences with regard to these skills. The study included 816 Grade 1-learners (419 boys and 397 girls). The Bruininks-Oseretsky Test of Motor-Proficiency, second edition (BOT-2) was used to evaluate the children's strength and agility skills. The results showed meaningful gender differences with respect to the strength skills of the learners, since boys performed better in the standing long jump (p=0.001) and push-ups (p=0.001) and girls did better in the wall-sit (p=0.044). Gender differences were found also when considering agility skills. Boys performed significantly better in the 15m-shuttle run (p=0.001) and the girls did significantly better in the sideways step over a balance beam, and one-legged and two-legged sideways hops. Grade 1-learners exhibit sufficient strength and agility skills while gender differences were *noticeable in the strength and agility skills of these learners.*

Key words: Motor proficiency; Bruininks-Oseretsky Test; Speed; Agility; Strength; Grade 1-learners.

INTRODUCTION

Motor development plays an important role in a child‟s life and enables the child to participate in kinetic activities, which help the child not only to be physically active, but also with social interaction and personal growth (Barton *et al.*, 1999; Goudas & Giannoudis, 2008). Furthermore, good motor skills are very important for the young child because these are the building blocks for more complex gross motor skills (Goodway & Savage, 2001; Vidoni & Ignico, 2011). According to Gallahue and Donnelly (2003), children move through four phases of motor development (from birth to adulthood). Children between the ages of seven and 10 years are in the last phase of development, which is known as the sport-related movement phase. Due to the increase in the prevalence of motor delays in children (Okely *et al.*, 2001; Dimitrios *et al*., 2007) and increased inactivity (Ara *et al*., 2004; Janssen *et al.*, 2004), many children never reach the sport-related movement phase, which is central to specialisation in sport.

Sport is recognised as an enriching medium for child development (Goudas & Giannoudis, 2008) as it helps the child not only to be physically active, but also with social interaction and personal growth (Barton *et al*., 1999; Goudas & Giannoudis, 2008). Physical activity is a large part of sport participation, which, according to Pienaar (2009), is not only advantageous

to a child‟s current health status, but also forms a stronger basis for the maintenance of good health throughout their entire lives. However, it is of central importance to develop the necessary skills and abilities through motor and physical activities at an early age to form an adequate foundation for sport skills.

Physical activity can be defined as all forms of movement associated with an increase in energy consumption (Trudeau & Shephard, 2010). Research has shown that physical activity contributes to an improvement in children‟s general health (Boreham & Riddoch, 2001; Robert & Zoeller, 2007), as well as their general health status as adults, since there is the trend that active children become active adults (Boreham & Riddoch, 2001). Robert and Zoeller (2007) found that physical activity prevents weight gain and maintains weight loss, and this is an important consideration knowing that the occurrence of overweight and obese children is becoming a general trend these days (Ogden *et al.*, 2002). Physical activity also contributes to the improvement of academic performance (Dwyer *et al.*, 2001) involving learning, memory, concentration and cognitive development (Trudeau & Shephard, 2010). Physical activity further helps to improve self-image (Dwyer *et al*., 2001; Tracey & Erkut, 2002; Piek *et al.*, 2006), socialisation (Trudeau & Shephard, 2010) and increases the development of motor skills and physical fitness (Okely *et al*., 2001).

Sherrill (2004) and Gallahue and Ozmun (2006) define physical fitness as the characteristics that an individual has that are related to the person‟s ability to perform physical activities. According to Gallahue and Donnelly (2003), physical fitness is sub-divided into physical and motor fitness. Muscle strength and strength are classified as part of physical fitness and increases commensurate with age from the early childhood years up to adolescence (Gallahue & Donnelly, 2003; Sherrill, 2004; Pienaar *et al*., 2012). Agility is a component of motor fitness (Winnick, 2005; Ortega *et al*., 2007; Pienaar *et al*., 2012) and can be seen as the ability to move fast and to change direction, while maintaining control and balance. The combination of speed, balance, strength and coordination is also an important part of agility (Annesi *et al*., 2005). Children‟s freedom of movement can be limited by inadequate strength as it forms an important part of the execution of all motor skills (Payne & Isaacs, 2008). In addition, strength is important to improve the overall fitness and health of sportspeople and to prevent injury (Chad *et al.*, 1999; Kraemer & Fleck, 2004), while agility is of special importance for the improvement of balance and coordination and is made up of a combination of acceleration, explosiveness and reaction time (Lori *et al*., 1998). The research of Ball *et al*. (1992) and Baker and Newton (2008) have shown that there is a direct relationship between sufficient strength and agility and performance in sport.

According to Haywood and Getchell (2009), strength, speed and agility improve with age during the middle childhood years and adolescence, but the pattern of improvement is influenced by several variables, such as body size, growth, maturation and gender, and to a certain extent motor competence and level of physical activity. Studies in various countries have reported that children now days have inadequate physical and motor fitness skills when considering components, such as aerobic fitness, strength, agility and perseverance (Volbekiene & Griciute, 2007; Keller, 2008; Mak *et al*., 2010).

When it comes to gender differences related to physical fitness, several research studies have found differences (Prista *et al*., 2003; Saygin *et al*., 2007; Volbekiene & Griciute, 2007; Lazzer *et al*., 2009). A South African study by Monyeki *et al*. (2003) on seven- to 14-year-old children from disadvantaged communities found meaningful gender differences for the following tasks: standing long jump; sit-and-reach; sit-ups, bent arm suspension; agility; and 1600m running. Prinsloo and Pienaar (2005), with their study on four- to eight-year-old South African children of farm workers showed that the performance of standing long jump of girls was better than that of the boys, while the boys had a stronger handgrip than the girls did. Furthermore, gender differences in strength skills can be ascribed to differences in muscle size, segment length and to a certain extent muscle use (Thomas & French, 1985; Castro *et al*., 1995).

The literature indicates that boys do better in activities that require speed and strength, whereas girls do better with balance and fine motor activities (Malina & Bouchard, 1991). However, there are authors that have reported no gender differences regarding strength and agility. In the study of Holm *et al*. (2008), there were no significant gender differences regarding the strength of children, while research of Saygin *et al*. (2007) revealed that there were no gender differences with regard to agility skills.

After an examination of the literature available on the strength and agility skills, it seems that there is a lack of research on the profiles of Grade 1-learners in the North-West Province of South Africa. What is more, there seems to be a scarcity in the availability of literature that addresses the influence of gender on the development of strength and agility skills.

PURPOSE OF STUDY

The purpose of this study was firstly to establish the current profile of the strength and agility skills of Grade 1-learners in the North-West Province and secondly, to investigate gender differences between these Grade 1-learners where strength and agility skills are concerned. The results of the study could contribute to a profile of the strength and agility skills of Grade 1 boys and girls in the North-West Province. These results could provide Kinderkineticists and educators with norms regarding the Grade 1-learners in order to make recommendations on how the learners should spent their time during physical education lessons, as well as which skills need to be improved in these learners to help them perform better during motor skills and school sport. The results of this study could also provide some guidelines for Kinderkineticists to develop motor intervention programmes to improve these skills.

METHODOLOGY

Research design

This research is part of a longitudinal study (the North-West Child-Health-Integrated-Learning and Development Study: NW-CHILD study), stretching over a period of 6 years (2010-2016). This study comprises of baseline measurements (2010) and 2 follow-up measurements (2013 & 2016) on a selected group of learners residing in different areas of the North-West Province of South Africa. For the purpose of the current research, only data from the baseline measurements (2010) of the Grade-1 learners have been incorporated.

Research procedure

The North-West University Ethics Committee (No. 00070- 90-A1) granted ethical approval for the research. The Department of Basic Education of the North-West Province consented to doing the research in the schools. The different school principals of the identified schools gave their permission to collect data during school hours. Sixty Grade 1-learners were selected randomly in each school and the informed consent forms completed by the parents of these learners were collected. The learners whose parents reacted positively participated in the testing.

Participants

The aggregate number of Grade 1-learners in the North-West Province of South Africa that served as the target population and participated in the NW-CHILD study, included 816 learners. The sample was selected by means of a stratified randomised sample in cooperation with the Statistical Consultation Service of the North-West University. The sample was selected from a list of schools in the North-West Province that was provided by the Department of Basic Education. The schools in the North-West Province are grouped into 4 education districts with 12 to 22 regions each. In each region there are between 12 and 47 schools. Regions and schools were selected randomly from this list with regard to population density and school economic status (Quintile 1 schools from poor economical areas, to Quintile 5 schools from affluent economical areas). Twenty schools with a minimum of 40 children per school and with an equal division of genders were involved in the study.

All learners with physical disabilities attending these mainstream schools, as well as all physically ill children on the day of the testing were excluded from this study. If the learner was younger than 6 years or older than 7.11 years, he or she was also excluded from the study.

Measuring instrument

The *Bruininks-Oseretsky Test of Motor-Proficiency, second edition (BOT-2)* (Bruininks & Bruininks, 2005), was used to evaluate the children‟s strength, speed and agility skills. This test battery is a standardised, norm-based and individual application instrument used to measure the efficiency of children‟s fundamental movement skills in 4 motor areas (Poulsen *et al.,* 2011). This measuring instrument is suitable for use with 4- to 21-year-olds (Bruininks & Bruininks, 2005).

The strength, running speed and agility sub-items consist of 5 activities each. The strength component includes the following items: standing long jump (distance in cm); push-ups (number performed correctly in a given time); sitting against a wall (time in seconds the position could be held); sit-ups (number performed correctly in a given time); and the V-sit (time in seconds the position could be held). The running speed and agility component includes the following items: a 15m shuttle run (speed in seconds); side hops over a balance beam; one-legged standing jumps; one-legged side hops; as well as two-legged side hops (number performed correctly in a given time).

During the execution of a test component, the child was allowed 2 attempts, of which the best raw score was used for further processing. The raw score was processed to a standardised score, of which the total score of a subtest was used to calculate the scale score. This scale score was used in turn to get a total standard count for the different subtests respectively. The percentile on which the child lies when considering the norms of his/her age group was determined from the compound standard scores. There are 5 categories for the classification of strength, running speed, agility and balance skills based on the scale score, namely far below average (≤5), below average (6 to 10), average (11 to 19), above average (20 to 24) and far above average (≥25). The test battery has a validity value of r= 0.75 (Bruininks & Bruininks, 2005).

With the administration of the tests, if the test subjects could not speak English, trained interpreters were used to communicate the instructions of the evaluator to the test subjects. Trained Kinderkineticists administered all the tests, where each Kinderkineticist was responsible for only 1 test. This was done to ensure consistency during data collection.

Statistical analysis

For data processing, the STATISTICA computer package (Statsoft, 2010) of the North-West University was used to analyse the data. Statistical consultation services from the North-West University were asked to help with the data analysis. For descriptive purposes, data was, firstly, analysed using means (M), standard deviations (SD), and minimum and maximum values. The independent t-test was applied to determine gender differences with regard to the learners‟ strength and agility skills. The level of statistical significance was set at $p \leq 0.05$. Effect sizes (d) were calculated to determine the practical significance of the results by dividing the differences in the mean by the largest standard deviation of the test results. For the interpretation of practical significance, the following guidelines were used: d≥0.2 indicated a small effect, d≥0.5 a medium effect and d≥0.8 a large effect (Cohen, 1988).

Lastly, a 2-way frequency table was used to compare the classifications of the boys and girls. The Pearson Chi-square served to indicate the significance of the results and the accepted level of statistical significance was set at p≤0.05. The strength of the correlations are represented by the phi-coefficient with w>0.1 indicating a small effect, w>0.3 a medium effect and w≥0.5 a large effect (Steyn, 2002).

RESULTS

Table 1 summarises the demographic information of the participants of this study.

TABLE 1. **AGE OF GRADE-1 LEARNERS ACCORDING TO GENDER**

Participants	**N**	**M±SD**
Total Group	816	6.84±40.39
Boys	421	6.86±0.39
Girls	395	6.81±0.38

N= Number of test subjects M= Mean SD= Standard Deviation

Independent t-tests were conducted to determine the significance of gender differences with regard to strength and agility skills (Table 2 and Table 3).

Table 2 shows that statistically (p≤0.05) and practically (d≥0.1), significant gender differences are noticeable for the tests on strength, where the boys did better in the standing long jump and push-ups, while the girls performed better only in the wall-sit. Although the boys had better scores than the girls in sit-ups and V-sit, there were no statistical or practical differences. For running speed and agility, statistically (p≤0.05) and practically (d≥0.1), significant gender differences were once again found where the girls outperformed the boys in 3 of the components (side hop, 1-legged side hop and 2-legged side hop), and the boys performed better than the girls in the 15m shuttle run.

TABLE 2. **GENDER DIFFERENCES REGARDING STRENGTH AND RUNNING SPEED AND AGILITY SKILLS**

	Boys (n=421)	**Girls (n=395)**	**Significance of differences**			
Variables	**M±SD**	**M±SD**	**df**	**t**	**p**	**d**
Strength						
Standing long jump	37.41±8.77	33.29±6.75	814	7.48	<0.001*	0.5##
Push-ups	10.26±5.55	8.76±5.49	814	3.89	<0.001*	0.2#
Sit-ups	3.91±4.31	3.48±4.13	814	1.44	0.150	0.1
Wall-sit	42.98±18.53	45.42±18.18	814	1.90	0.05*	0.1
V-sit	41.29±19.44	39.96±19.81	814	0.96	0.409	0.1
Running speed & agility						

15m-shuttle run	9.48±1.94	9.87±0.90	814	3.70	<0.001*	0.2#
Sideways step	22.55±10.96	26.57±8.56	814	5.83	<0.001*	0.4#
Standing one-legged jump	36.44±7.55	36.21±5.91	814	0.48	0.635	0.03
One-legged sideways jumps	15.42±5.71	16.44±6.57	814	2.38	0.017*	0.2#
Two-legged sideways jumps	18.67±6.13	19.65±6.10	814	2.30	0.022*	0.2#

M= Mean; SD= Standard Deviation; t= t-value; df= Degrees of freedom; p= Significant difference p<0.05*; d= Effect size (practical significance when d= 0.2# small and d= 0.5## medium)

Table 3 shows the strength and agility results of the Grade 1-learners. The results with regard to strength skills reveal that there were statistically (p≤0.05) and practically (d≥0.2), significant differences between the aggregate scale score, age equivalent of the boys and girls and aggregate age equivalent. Furthermore, the strength of the boys‟ average age equivalent is significantly higher than the chronological age of the boys and girls (7.46 compared to 6.86 and 7.01 compared to 6.81 respectively). In the case of agility skills, no statistical (p≥0.05) or practical (d≤0.2) significance were found with regard to the scale score and age equivalent of the boys and girls. It seems that the age equivalent of the boys and girls are significantly higher than their chronological age (8.13 compared to 6.86 and 8.29 compared to 6.81

respectively). Lastly, for the strength and agility standard score, statistical significant (p=0.008) differences were found between the boys and girls, where the boys outperformed the girls (54.52 vs. 53.04).

TABLE 3. **GENDER DIFFERENCES REGARDING STRENGTH AND RUNNING SPEED AND AGILITY SKILLS BASED ON SCALE SCORES**

Variables	Boys (n=421) M±SD	Girls (n=395) M±SD	Significance of differences df	t	p	d
Strength						
Total scale score	16.26±3.36	15.34±3.73	814	3.69	<0.0001*	0.25#
Age equivalent of boys and girls (yrs)	7.46±1.53	7.01±1.51	814	4.24	<0.0001*	0.29#
Combined age equivalent (yrs)	7.52±1.55	7.00±1.48	814	4.94	<0.0001*	0.34#
Running speed & agility						
Total scale score	17.54±3.51	17.76±3.52	814	0.45	0.655	0.06
Age equivalent of boys and girls (yrs)	8.13±1.92	8.29±2.25	814	1.04	0.299	0.07
Combined age equivalent (yrs)	8.46±5.01	8.35±2.20	814	0.93	0.695	0.02

Strength & Agility SS	54.52±7.24	53.04±8.81	814	2.64	0.008*	0.17

M= Mean; SD= Standard Deviation; t= t-value; df= Degrees of freedom; p= Significant difference p<0.05*; d= Effect size (practical significance when d=≥0.2# small and d=≥0.5## medium); SS= Standard Score

Lastly a 2-way frequency table was used to show the strength and agility skills according to skill categories (Table 4).

Table 4 shows the strength skills of the Grade 1-learners in the different skill categories for the aggregate group and for the boys and girls separately. For strength, there was 1 girl in the far *below average category* and for running speed and agility there was 1 boy in the far below average category. The majority of the learners were in the *average* skills category for strength (boys: n=320, 76.01%; girls: n=293, 74.18%), and running speed and agility (boys: n=287, 68.17%; girls: n=259, 65.57%). The second largest number of learners were in the *above average* category for strength (boys: n=70, 16.63%; girls: n=54, 13.67%), and running speed and agility (boys: n=115, 27.32%; girls: n=115, 29.11%). Although gender differences occurred regarding the representation of the different strength and agility categories, no statistical or practical significant differences were found between the boys and girls in the *strength skills* (p=0.118; w=0.09) and *running speed* and *agility skills* (p=0.680; w=0.05).

TABLE 4. **STRENGTH AND AGILITY OF BOYS AND GIRLS BASED ON SKILL CATEGORIES**

Variables	**1 n (%)**	**2 n (%)**	**3 n (%)**	**4 n (%)**	**5 n (%)**
Strength					
Boys (n=421)	0 (0)	31 (7.36)	320 (76.01)	70 (16.63)	0 (0)
Girls (n=395)	1 (0.25)	46 (11.65)	293 (74.18)	54 (13.67)	1 (0.25)
Group (N=816)	1 (0.12)	77 (9.44)	613 (75.12)	124 (15.20)	1 (0.12)
Agility					
Boys (n=421)	1 (0.24)	13 (3.09)	287 (68.17)	115 (27.32)	5 (1.19)
Girls (n=395)	0 (0)	13 (3.29)	259 (65.57)	115 (29.11)	8 (2.03)
Group (N=816)	1 (0.12)	26 (3.19)	546 (66.91)	230 (28.19)	13 (1.59)

1= Far below average; 2= Below average; 3= Average; 4= Above average; 5= Far above average; Strength: w= 0.09, p=0.118; Running speed & agility: w= 0.05, p=0.6803

DISCUSSION

The study aimed to determine the strength and agility skills of Grade 1-learners in the North- West Province. A further goal was to determine whether there were gender differences regarding the strength and agility skills of these Grade 1-learners.

The results show that the average age equivalent of the total group for the strength skills was 7.27 years and for agility skills, it was 8.41 years. The average age equivalent for the strength and agility skills was statistically significantly (p<0.05) higher than the average chronological age of the aggregate group (6.84 years). The results furthermore revealed that most of the aggregate group of participants were in the average skills category for strength (n=613, 75.12%) and agility skills (n=546, 66.91%), while only 77 (9.44%) of the participants were in the below average skill category for strength and 26 (3.19%) for speed and agility. The results of this study are in contrast to the findings of Mak *et al*. (2010) on 12- to 18-year-old children and of Volbekiene and Griciute (2007), on 12- to 16-year-old children where it was posited that children have insufficient strength and agility skills. However, the mentioned research was conducted with older children and the researchers were of the opinion that a decrease in daily activity is possibly the main contributing factor to insufficient skill. It is speculated that a possible reason for the high average age equivalent for strength and agility skills of these Grade 1-learners can be that they were more physically active, play outside more, which could lead to more free play.

Regarding gender differences related to the raw scores of the strength skills of the learners, there were statistically significant differences between the boys and girls, where boys performed better in the standing long jump and push-ups. This corresponds with the findings of Prista *et al*. (2003) and Saygin *et al*. (2007), on 6- to 18-year-old children. The research by Lazzer *et al*. (2009), involving 8- to 12-year-old learners, found that the absolute peak strength values of the boys were higher than that of the girls.

Research by Milanese *et al*. (2010) on 6- to 12-year-old children also shows that boys performed the standing long jump better than the girls did. The results of this study are further confirmed by a South African study conducted by Monyeki *et al*. (2003) on 7- to 14-year-old children who also reported significant gender differences for the standing long jump, where boys did significantly better than the girls did. In a study conducted by Prinsloo and Pienaar (2005), involving 4- to 8-year-old South African children of farm workers, the boys performed better compared to the girls on the standing long jump. The better performance in the push-ups by boys could be explained possibly by the fact that boys are somewhat stronger in their upper extremities than girls are (Pienaar *et al*., 2012).

According to Pfister (1993), boys are more competitive and they make use of a larger play area, which is advantageous for strength development, while girls tend to play in a more collaborative and passive manner. Boys‟ activities also include more sport elements, while girls‟ free time activities are more sedentary in nature (Pfister, 1993). Parents tend to emphasise and encourage the gross motor skills of boys more than with girls, and this leads to rougher play, which in turn promotes strength skills (Maccoby & Jacklin, 1974). This study also found that boys and girls performed similarly with the sit-ups and V-sit, which corresponds with the findings of Pienaar *et al*. (2012) who found that muscle and strength development in both genders progress the same up to about the age of 11.

Gender differences also occurred during the agility skills, where the girls did statistically significantly better in the „sideways step over a balance beam‟ and „two-legged sideways jump‟ when compared to the boys. These agility sub-items require balance, preciseness and accuracy. This corresponds with the research findings of Keogh (1965), who showed that girls do better in hop, skip and jump activities, which require more preciseness and accuracy of movement. However, the boys did statistically significantly better in the 15m shuttle run when compared with the girls, which is in agreement with previous research findings (Monyeki *et al*., 2003; Lazzer *et al*., 2009; Milanese *et al*., 2010), which show that boys do better in activities that require speed.

RECOMMENDATIONS AND CONCLUSIONS

The results of this study should be assessed in light of a few shortcomings picked up during the course of the study. The BOT-2 only evaluates certain aspects of physical fitness and one recommendation is, therefore, that other test batteries be used as well to compile a complete physical fitness profile of the Grade 1-learners. A second recommendation is that socio- economic class differences be taken into account when the strength and agility skills of these learners are evaluated, since these factors could have an effect on children's physical fitness (Duncan *et al*., 2008; McVeigh & Meiring, 2014; White *et al*., 2014). A third recommendation is that educators and professionals in practice who work with this population must be trained to introduce the correct intervention programme to improve the strength and agility skills of these learners. Lastly, a follow-up study is recommended to determine whether the strength and agility skills of these children would change with age because it seems that as the learners get older they seem to participate less in physical activity.

Although the study had a few shortcomings, the results showed that Grade 1-learners in the North-West Province had adequate strength and agility skills. The study also revealed that

there were gender differences with regard to strength and agility skill, where the boys in general performed better with strength skills than the girls, while the girls outperformed the boys regarding the agility skills.

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InPUTTER: CONCEPT AND EVALUATION OF AN ENGINEERED GOLF PUTTER

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ABSTRACT

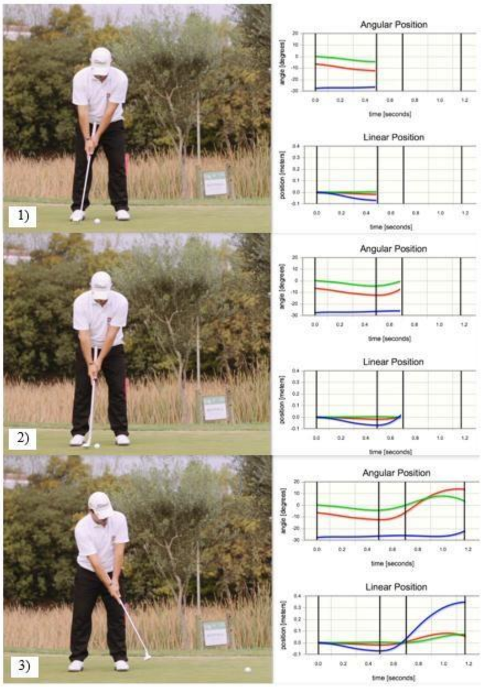
InPutter was designed for research, analysis and training to improve the performance in golf putting. The engineered putter is equipped with an inertial measurement unit (IMU), force sensitive resistors and heartbeat radio-frequency receiver compatible with Polar electrocardiogram (ECG) transmitters. With a high frequency of 100Hz, the device can be combined easily with other alternatives, such as cameras, to increase the range of applications and variables for further analysis. The putter is able to maintain energy autonomy (battery capacity) for up to four hours, which is ideal for both 'Pitch & Putt' and traditional golf games. After describing the hardware and software development, this article highlights and assesses the benefits of InPutter by validating experimentally its function using the data collected from professional/expert golfers. The data reveals a variety of different putting techniques and strategies. InPutter, with its innovative technologies, is able to measure all aspects of a putting stroke with great precision.'

Key words: Smart putter; Golf putting; Putting signature; Kinematic pattern.

INTRODUCTION

Golf is one of the most well-known short games in sport, wherein competing players need to introduce the ball into the hole with the fewest number of strikes. According to Pelz, the putting technique, or simply putting, is defined as a light golf stroke made on the green in an effort to place the ball into the hole (Pelz, 2000). Note that this movement represents about 43% of the strokes in a golf game (Dias & Couceiro, 2015). In that sense, authors, such as Pelz (2000), Hume *et al*. (2005), Couceiro *et al*. (2013a) and Dias *et al*. (2014), divide the golf putting movement execution into three phases (Figure 1).

1) *Backswing*: Propulsion of the putter upwards and backwards in relation to the ball. This phase is necessary to position and align the golfer's hub centre and the club head;
2) *Downswing*: Retraction of the putter downwards and forwards in relation to the ball. This phase starts where the backswing phase ends, and finishes immediately before the club head strikes the ball in the correct plane under maximum velocity. Contact/ball impact is the instant when the club head strikes the ball; and
3) *Follow-through*: Starts immediately after the *ball impact* and is the deceleration phase benefiting from the eccentric muscle contraction. This is an inertial phenomenon inherent to the golf putting movement.



1) = Backswing; 2)= Downswing and ball impact; 3)= Follow-through

FIGURE 1. **PHASES OF GOLF PUTTING**
Sequence executed by the European Champion of pitch and putting: Hugo Espirito Santo (Dias & Couceiro, 2015:8)

Although Pelz (2000) states that golf putting is a simplistic movement with little to no struggle regarding its motor execution the same author emphasises that, within such deceptive simplicity, a wide range of variables that can make this quite a complex movement, needs to be taken into account (Pelz, 2000). Notwithstanding the relevance of putting in the outcome of the game, most of the research studied this movement mainly in laboratory settings (Dias *et al.*, 2014). On the other hand, alternatives, such as the SAM PuttLab, are costly and far from being portable and easy-to-use (Marquardt, 2007). Therefore, this article presents the development of an innovative smart device, denoted as InPutter, that was designed to provide a professional analysis of putting and not only to "tune" the performance of professional golfers, but to also promote this modality within the context of learning, training and competition. In this sense, InPutter is able to compute the most relevant process variables inherent in putting, thereby providing, in real-time and over the Internet, raw and pre- processed data by benefiting from state-of-the-art methods (Couceiro *et al*., 2013b; Dias *et al*., 2014).

Given the above, the science behind InPutter will be described briefly and the working principles, considered for acquisition and analysis of putting, will be presented. This will include a description of the system architecture, which includes the technical specifications of the hardware and how these are organised. An evaluation of InPutter was carried out, both in

terms of putting performance assessment (accuracy and precision of the measures provided), and ecological validity, by considering a sample of 14 professional/expert right-handed adult male golfer volunteers and, under different practice conditions and constraints.

METHODOLOGY

Working principles and system components of InPutter

Most of the traditional research around sport science is centred on the product variables (*did the ball enter the hole or not*?). Yet, many researchers have been working towards a better understanding of the process measurements of motor execution (*why the ball did not enter the hole*?). By studying these variables, one may further understand the reasons behind the stability and variability of the final outcome (Dias & Couceiro, 2015).

In brief, as a smart device, InPutter requires minimal configurations, depending on the context and requirements of the golfer, coach or researcher. The following sections describe the acquisition, pre-processing and analysis considered during the design of InPutter.

Acquisition

This section outlines the data acquisition strategy adopted to analyse all golf putting process variables fully. Considering the limitations of the current state-of-the-art described in the previous section, the acquisition strategy adopted for InPutter focuses on 2 key premises: 1) to provide a high acquisition rate fitted to golf putting; and 2) to enable the acquisition of the data in any context, without any installation or calibration. Regarding its several phases, the literature reveals that golf putting may take approximately between 1 to 2.5 seconds and the linear velocity is always inferior to $1m.s^{-1}$ (Dias *et al*., 2014). Considering an acquisition rate of 100Hz, this data implies that one would be able to obtain about 100 to 250 samples for each put and from each sensing source equipped on the device. On the other hand, in the worst-case scenario of putting with a linear velocity of $1m.s^{-1}$, one could obtain an average error of 10mm. Considering an average putter size of 88.9cm according to PGA

(Professional Golfers Association) standards[1], this linear measurement is translated into an angular measurement of approximately 0.6 degrees. Hence, and given the preponderance of angular measurements over linear measurements in this type of pendulum-like movement (Nelson & Olsson, 1986), the acquisition rate of InPutter was defined as 100Hz.

The second premise regarding the portability and usability of InPutter as an acquisition device was guaranteed by embedding all the sensory components, pre-processing and wireless communication within the putter. Without resorting to any pre-installation or pre-calibration, as all other alternatives available in the market, one can start collecting data by simply turning on InPutter. Given that InPutter integrates all data into a single device, the need for any external references is surpassed. In addition, the general InPutter calibration is performed during the development process within laboratory context, thus avoiding any calibration process that may be susceptible to human error. Despite the advantages of InPutter over the alternatives, the analysis of the putting performance still focuses on 3 sensorial

[1]http://www.pga.com/golf-instruction/lesson-learned/putting/putter-fitting-most-important-club-in-your-bag-lesson

sources: an IMU sensor, which includes 3D gyroscope, 3D accelerometer and 3D magnetometer; an array of force sensors; and a heartbeat radio-frequency receiver compatible with Polar electrocardiogram (ECG) transmitters[2]. Hence, the data likely to be obtained, after the initial calibration performed during the development of InPutter, are the angular position (in degrees), the linear acceleration (in $m.s^{-1}$), the impact force on the ball (in KgF.cm^{-2}) and heart rate (in beat.min^{-1}). Now it would be necessary to compute any remaining properties to analyse putting in its entirety.

Pre-processing

It is noteworthy that InPutter already comprises a pre-processing procedure. However, that pre-processing, denoted as low-level pre-processing, is only devoted to the transformation of the acquired measures by benefiting from well-tested mathematical functions provided by the sensors firmware and filtering techniques for the Inertial Measurement Unit (IMU), namely quaternion-based Kalman filtering algorithms (Marins *et al*., 2001). This low-level procedure is necessary to prepare the data for further high-level pre-processing that shall occur on the server side to benefit from more CPU (Central Processing Unit) processing power for real- time data analysis over the Internet.

Data analysis of 'InPutter'

While the Graphical User Interface (GUI), called InPutter Visualiser, allows observation of the putter's trajectory, both raw and pre-processed data can be found by exporting the putting trial to Microsoft Excel. According to the current state-of-the-art, the most relevant properties of these time-series observations, provided by the GUI, are: impact force (KgF.cm^{-2}); impact duration (μs); location of the ball in the putter's face during impact; duration of the movement and each phase (s); amplitude of the angular position (degrees); amplitude of the linear position (m); peak of the angular velocity (degrees.s^{-1}); peak of the linear velocity ($m.s^{-1}$); peak of the angular acceleration (degrees.s^{-2}); peak of the linear acceleration ($m.s^{-2}$); face angle (degrees); declination angle (degrees); and heart rate (beat.m^{-1}).

Other complementary measures, such as the impact force applied to each cell of the putter's face or the heart rate over the past 5 readings can be found by exporting the data. Reference should be made to the current literature for a detailed description of all these process variables, which include the works of Pelz (2000), Roberts *et al*. (2001), Hume *et al*. (2005), Couceiro *et al*. (2013a) and Dias *et al*. (2014).

System architecture

InPutter was built in its entirety to be classified as a smart device to provide easy-to-use functionalities, while maintaining its connectivity to the Internet; the putter only needs to be turned on by means of the pressure switch. Two situations may then occur. If InPutter' has not been configured yet with any WiFi network available nearby, it will remain offline. All putting trials made will then be stored in an external memory device (flash memory) and automatically uploaded to Ingeniarius Cloud[3] once it can get connected to the Internet (in

[2]http://www.polar.com

[3]https://cloud.ingeniarius.pt

range of a WiFi network previously configured). When InPutter has been configured with WiFi networks in its vicinities, it will automatically connect to the network with the highest received signal strength indication (RSSI). Setting up a new WiFi network was done by using Texas Instruments SmartConfig technology[4], in which one only needs to be connected to the desired network with another device (for example, smartphone, tablet, etc.), and run the application thereof.

All this plug-and-play and easy-to-use features are only possible due to the hardware choices. Figure 2 shows the technical specifications of the hardware and how it is organised.

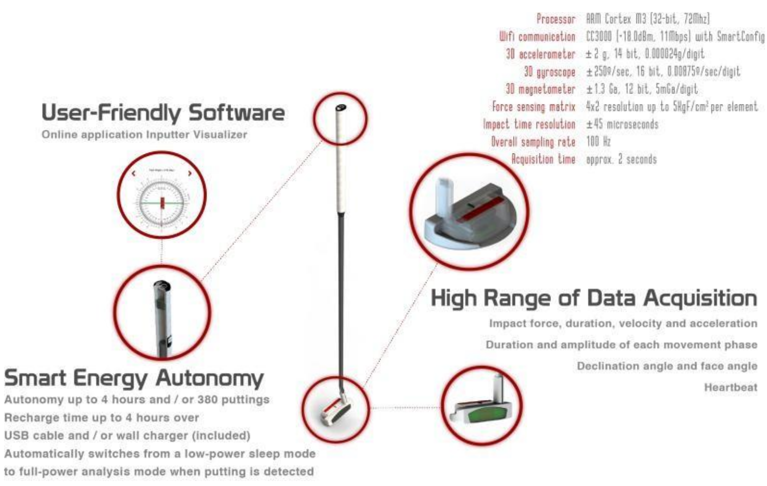


FIGURE 2. **INPUTTER HARDWARE STRUCTURE**

Application of evaluation study

This study involves evaluating InPutter with a sample of 14 adult male golfers (43.22±13.98 years), volunteers, right-handed and professionals/experts (2.78±1.50 pitch and put handicap).

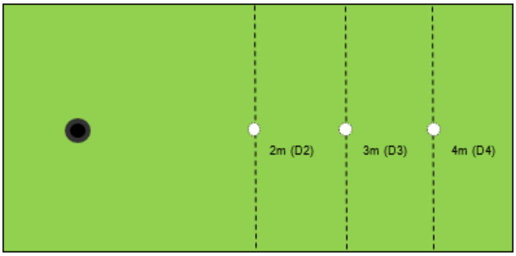


FIGURE 3. **EXPERIMENTAL FIELD SET-UP**

[4]http://processors.wiki.ti.com/index.php/CC3000_Smart_Config

The trials were conducted outdoors, on a regular green, at Quinta das Lágrimas Golf Club, Coimbra, Portugal. Three circles, the size of a golf ball, were marked on the green using ball markers, defining the exact location for the execution of the golf putting at 2m (D2), 3m (D3) and 4m (D4) away from the hole (Figure 3).

Each participant performed 3 practise trials at a distance of 2m away from the hole. During this preliminary experiment, the players were not given any verbal feedback about their movement nor about the result provided by InPutter, but they had visual access to the ball trajectory and stopping position. Afterwards, 30 trials were performed at each distance of 2m, 3m and 4m from the hole (a total of 90 trials).

RESULTS

The results presented will focus mainly on the data provided by InPutter (process variables).

TABLE 1. **COMPARISON WITH GOLF PUTTING DEVICES AVAILABLE ON THE MARKET**

Putting process variables	Values[1]	Dias *et al.*, 2014			InPutter		
		D2	D3	D4	D2	D3	D4
Backswing/downswing[2] (ds) amplitude [mm]	Mean	171	178	186	174	203	222
	SD	36	26	29	38	44	46
	CV%	21	15	16	22	22	21
Follow-through (ft) amplitude [mm]	Mean	292	365	414	353	434	481
	SD	42	44	52	67	86	88
	CV%	14	12	13	19	20	18
Speed of impact (vi) on ball [$m.s^{-1}$]	Mean	1.14	1.28	1.41	1.47	1.74	2.02
	SD	0.18	0.15	0.24	0.16	0.25	0.22
	CV%	16	12	17	11	14	11

Maximum acceleration (am) of putting [m.s^{-2}]	Mean SD CV%	5.48 0.62 11	5.45 0.33 6	6.04 0.56 9	6.51 1.19 18	7.63 1.98 26	8.67 1.94 22
Backswing (bs) duration time [ms]	Mean SD CV%	459 97 21	461 98 21	559 140 25	572 122 21	586 120 20	607 140 23
Downswing (ds) duration time [ms]	Mean SD CV%	290 59 20	294 48 16	298 64 22	304 77 25	301 79 26	297 81 27
Follow-through (ft) duration time [ms]	Mean SD CV%	437 91 21	469 79 17	493 100 20	400 112 28	421 115 27	412 107 26

mm= millimetres; m= metres; ms= milliseconds; SD= Standard Deviation; CV%= Coefficient of Variation; m.s^{-1}= metres per second (power of -1); m.s^{-2}= metres per second (power of -2); [1] Overall results; [2] Amplitudes of both backswing and downswing are the same.

For the experimental evaluation, attention was focused on the most common values presented in the literature (Dias *et al.*, 2014), concerning the backswing and downswing amplitude, follow-through amplitude, speed of impact on the ball, maximum acceleration of the put, backswing duration time, downswing duration time and follow-through duration time. It can be observed in Table 1 that the data retrieved with InPutter follows a similar tendency with the distance to the hole regarding the amplitude, velocity and acceleration of the put. However, the duration of each phase does not follow an increasing tendency as was also found by Dias *et al*. (2014).

Two important variables should be considered in this comparison. The study presented by Dias *et al*. (2014) involved a sample of 10 professional/expert golfers and was accomplished in an indoor artificial green, as opposed to the real green used in this work. Moreover, in the study of Dias *et al*. (2014), the data was collected entirely by means of a front camera and semi-manual tracking under MatLab, where human error cannot be ignored. Couceiro *et al*. (2013b) provide a detailed description of the detection and estimation methods considered.

Even if the latter is ignored, the literature is clear that there are differences in putting execution between different players (Sim & Kim, 2010), as well as the effect of artificial and real green surfaces (Drane *et al*., 2014). For instance, according to Delay *et al*. (1997), and as supported by the results in Table 1, the backswing/downswing amplitude of professionals (experts) is considerably larger than that of novice golfers. Another interesting feature provided by InPutter is the reliability and consistency of the data. The variability (SD) is generally smaller than what was observed by Dias *et al.* (2014), meaning that the deviation from the average (AVG) is smaller. This may be explained by the consistency of the kinematic estimation of the putting provided by the quaternion-based Kalman filtering algorithms (Marins *et al*., 2001), and followed by the Levenberg-Marquardt fitting method (Moré, 1978).

InPutter Visualizer

In this section, the different outputs from the GUI, named InPutter Visualizer, is presented as retrieved from 2 distinct players (Player 1 on the left and Player 2 on the right).

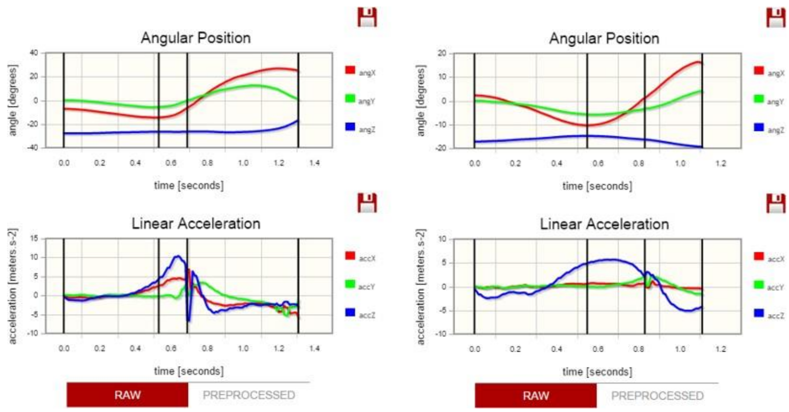


FIGURE 4. **ANGULAR POSITION AND LINEAR ACCELERATION: RAW DATA**

In Figures 4 and 5, Player 1 presents a small backswing and large follow-through, while Player 2 has a regular movement (almost a perfect sinusoid).

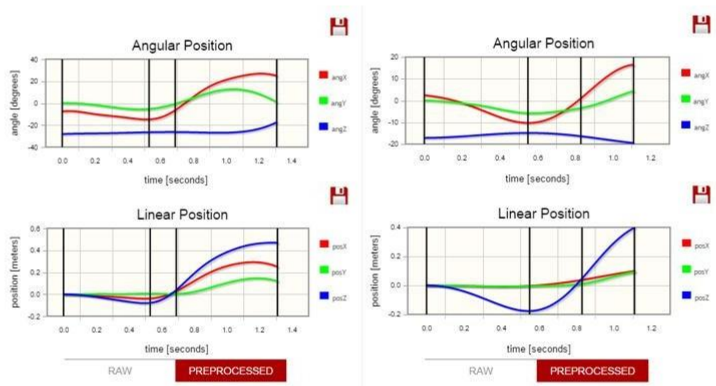
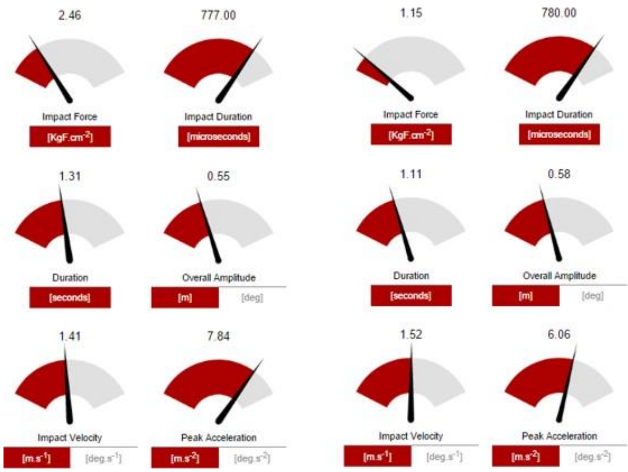


FIGURE 5. **ANGULAR POSITION AND LINEAR ACCELERATION: PRE-PROCESSED DATA**

Figure 6 shows several measures, like impact force, impact duration, duration, overall amplitude, impact velocity and peak acceleration. Although players perform differently, it can be observed in this figure that the impact duration and the overall amplitude are similar. However, Player 1 presents a larger impact force.



Impact force= $KgF.cm^{-2}$ Impact duration= µs Overall amplitude= m or deg Impact velocity= $m.s^{-1}$ or deg. s^{-1} Peak acceleration= $m.s^{-2}$ or deg^{-2}

FIGURE 6. **VALUES OF IMPACT FORCE, IMPACT DURATION, OVERALL AMPLITUDE, IMPACT VELOCITY AND PEAK ACCELERATION**

Figure 7 depicts the face angle. Although Player 2 is regular in terms of motion as observed in Figures 4 and 5, Player 1 presents a more accurate face angle (near zero degrees), which may be closely related to the fact that he also applied a smaller backswing.

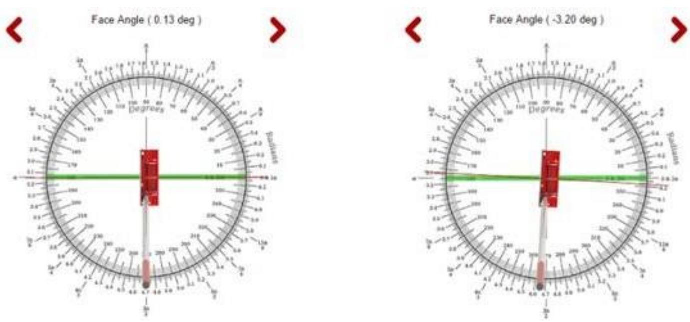


FIGURE 7. **FACE ANGLE (deg)**

As opposed to what was seen in the previous figure, Player 2 presented a declination angle that is considered more regular than the one presented by Player 1 (Figure 8).

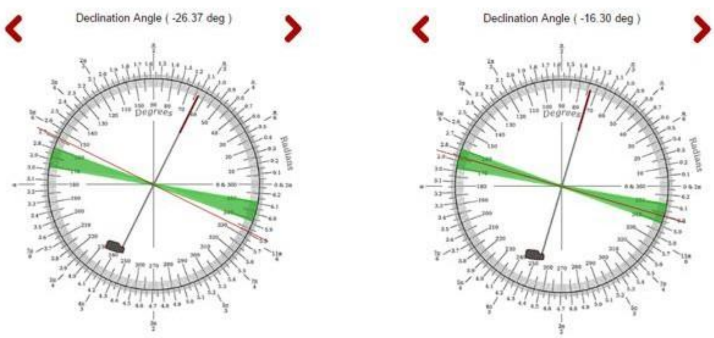


FIGURE 8. **DECLINATION ANGLE (deg)**

Figure 9 illustrates the position where the ball hit the face of the golf club during impact. It can be observed that, although both players seemed regular in this sense, Player 2 was able to hit the ball with the middle of the golf putter's face.

FIGURE 9. **IMPACT ON BALL WITH FACE OF PUTTER**

Finally, on analysing Figure 10, it was verified that both players presented a high heart rate. This could be ascribed to the succession of 90 putting trials they had to perform. Note that the green line in Figure 10 represents the heartbeat, wherein the R-R intervals can be observed.

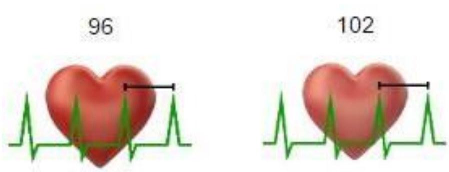


FIGURE 10. **HEART RATE (beat.m^{-1})**

Although there was a difference in the heartbeat of the 2 players, the difference was not significant and it can be considered fairly stable for the last 5 beats, as a different R-R interval with the naked eye (distance between peaks) cannot be observed.

DISCUSSION

The aim of this article was to show the innovative technology and science behind InPutter. The engineered putter allows one to measure all aspects of a putting stroke with high precision. In simple terms, golf putting can be learned in many different ways and by following many different methods (Couceiro *et al*., 2013a; Dias & Couceiro, 2015). Nevertheless, the individual variability underlying human motor behaviour makes this movement quite different from player to player, since the morphological and functional characteristics are distinct (Delay *et al*., 1997; Pelz, 2000). Additionally, the environmental context and other constraints (distance to the hole, number of people assisting the game, performance of opposing players, etc.), have a significant effect on the performance of a player (Dias *et al*., 2014).

All these factors have a decisive influence on how the golfer will hit the ball and adjust its action, namely the angular displacement of the putter, face and declination angles, applied force and all other process variables related with the motor execution (Sim & Kim, 2010). Moreover, golf putting also encompasses other relevant variables within the performance context, such as stability, routine, attitude and rhythm, as well as other aspects of personality, learning ability and motivation of players in the execution of this movement. One way to promote this consists on acquiring data about the motor performance and analyse it to identify and correct any technical inconsistencies (Dias & Couceiro, 2015). Although this can be done with cameras and other putting-specific devices available on the market, nothing can do it as well as the InPutter, as it maintains the ecological validity of the overall set-up, without additionally constraining the golfer with unrealistic situations (laboratory set-up, full- body suit, carrying additional equipment, among others).

PRACTICAL APPLICATION

InPutter is an engineered golf putter designed for research, analysis and training purposes. By benefiting from an internal IMU sensor and wireless technology, it is able to retrieve the most relevant golf putting process variables, namely the putter's trajectory over time, velocity, duration and amplitude of each phase, as well as the impact force on the ball. As InPutter does not require any camera systems, markers, or system infrastructure, and given its robustness, weight and design as any other traditional golf putter, it can be used in both

indoor and outdoor environments (Dias *et al*., 2014). Additionally, InPutter is an Internet-connected product that automatically connects to a cloud, thus allowing real-time debugging and monitoring over the Internet.

When compared with other products (Sam Puttlab), InPutter presents several advantages, such as it can measure heart rate and it is able to show a wide range of relevant golf putting process variables that other solutions cannot, namely the inclination angle, impact duration, impact force, follow through duration and follow through amplitude. Now, one can say that InPutter is the most complete engineered golf putter on the market.

CONCLUSIONS

The preliminary experimental evaluation showed that the data retrieved using InPutter is in line with the current state-of-the-art tools, namely with the multiple scientific works published by the authors behind the development of InPutter. Furthermore, InPutter offers a wider range of variables when compared to the alternatives, from which one may highlight the golfer's heart rate immediately before and during the putting, the impact force, duration and location where the ball hits the face of the putter, the mathematical kinematical model and 3D visualisation. Looking to the future, it is intended to validate the InPutter and benchmark it with other similar technologies.

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THE ABILITY OF PARENTS TO IDENTIFY GRADE 1-LEARNERS WITH DEVELOPMENTAL COORDINATION DISORDER AT HOME

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ABSTRACT

Developmental Coordination Disorder (DCD) is recognised as one of the most common developmental dysfunctions during childhood and a large number of children between 6 and 12 years of age are identified with DCD. The aim of the study was to examine the convergent validity of the classification of motor difficulties by Kinderkineticists-in-training, using the Movement Assessment Battery for Children-2 (MABC-2 Test), and the classification of motor difficulties by the parents of the participants, using the DCD Questionnaire '07 (DCDQ'07), to determine if parents possess the competency to identify DCD at home. Grade 1-learners (N=410) between the ages of 5 to 8 years participated (girls: n=226 [55%]; boys: n=184 [45%]). The ethnic groups represented were 67% Caucasian and 33% Black children. The results indicated 91% specificity for the DCDQ'07. In contrast, the sensitivity was only 23%. The kappa coefficient of 0.151 indicated a 15% convergent validity between the two assessment tools. Therefore, the parents in this study, who used the DCDQ'07, could not identify children with

DCD at home.

Key words: DCD (Developmental Coordination Disorder); MABC-2 Test (Movement Assessment Battery for Children-2); Developmental Coordination Disorder Questionnaire'07 (DCDQ'07); Grade 1-learners.

INTRODUCTION

DCD is recognised as one of the most common developmental dysfunctions during childhood (Ellinoudis *et al*., 2009). The literature indicates wide debate regarding the prevalence of DCD (Giagazoglou *et al*., 2011) and varies in relation to the diagnostic criteria that are used (Carslaw, 2011). According to the American Psychiatric Association (APA, 2013), DCD affects 5 to 6% of school-age children between five and 11 years of age, while Wilmut *et al*. (2007) indicated the prevalence of DCD to be between 5 to 10%. In South Africa (Bloemfontein metropolitan area), the prevalence of DCD was even higher, as it was found that 15% of learners had DCD (De Milander *et al*., 2014). Alarmingly, Pienaar (2004) and Wessels *et al*. (2008) reported that children in the North-West Province of South Africa had a significantly higher prevalence of DCD. They reported 61 and 52% respectively. Pienaar (2004) concluded that the norms of the Movement Assessment Battery for Children should be adjusted for South African children.

DCD can be defined as a marked impairment in the development of motor coordination that is not explicable in terms of general intellectual retardation or in terms of any specific congenital or acquired neurological disorder (APA, 2013). It is diagnosed in children who experience significant difficulties in motor learning and in the performance of functional motor tasks that are critical for success in their daily lives, such as activities at home (dressing themselves), school (handwriting), and during play (ball skills) (Edwards *et al*., 2011; Asonitou *et al*., 2012). These difficulties could be viewed as clumsiness, for example, dropping objects, in addition to the slow and inaccurate performance of motor skills, such as catching objects, using scissors or taking part in sport (APA, 2013).

Zwicker *et al*. (2012) argue that one of the major concerns regarding children with DCD is that often they are not diagnosed formally, but rather described by their parents and teachers as lazy or awkward. Furthermore, they state that the reason for not diagnosing these children is the lack of awareness of the disorder. The use of questionnaires is encouraged by Missiuna and Pollock (1995), as well as Wright and Sugden (1998), who state that numerous tools should be used to gather information from parents and teachers. Questionnaires may be used to identify young children in need of further assessment by professionals, who would use the normative assessment tools. However, the use of these questionnaires has both limitations and advantages.

In an attempt to identify children with DCD, several research tools, such as questionnaires for screening purposes and norm-referenced tests to measure the degree of movement difficulties, can be used (Barnett, 2008). In view of the high costs of norm-referenced tests, time- consuming processes and long waiting periods, screening tools are a cost-effective way of identifying children who might have DCD (Loh *et al*., 2009). Several screening tests and questionnaires have been developed to gather information, specifically from parents and teachers, concerning children's functional motor performance, for example, the Movement

Assessment Battery for Children Checklist (MABC-C) and the Developmental Coordination Disorder Questionnaire'07 (DCDQ'07) (Schoemaker *et al*., 2012).

The validity and reliability of the original DCD-Q has been investigated. It was found that this questionnaire is a valid and reliable tool and can be used for boys and girls (Schoemaker *et al*., 2008). It has been recommended that the test can be used with confidence for children between the ages of eight and 14 years and six months (Wilson *et al*., 2000). In 2009, Wilson and colleagues conducted another study using the same instrument and concluded that children as young as five years of age can be screened (Wilson *et al*., 2009). Brazilian researchers adapted the language and two of the items in the questionnaire due to cultural differences. The resulting questionnaire was found to be equivalent to the original DCD-Q. The DCDQ-Brazil also demonstrates acceptable validity and reliability (Prado *et al*., 2009). In contrast, Loh *et al*. (2009) found that the DCD-Q had a low sensitivity in detecting children with mild motor difficulties.

Regarding the limitations of the original DCD-Q, Wilson *et al*. (2000) indicated a 27% convergent validity between the therapist and the DCD-Q, demonstrating that the questionnaire did not identify children with motor difficulties as frequently as a therapist. Loh *et al*. (2009) also indicated that the DCD-Q was insufficient in distinguishing children with motor difficulties from those who did not experience any difficulties. Additionally, studies

using parents' reports have produced conflicting results (Faught *et al*., 2008). Another limitation arising from using questionnaires are that parents with attention deficit/hyperactivity disorder (ADHD) children tend to indicate that their children experienced motor problems, while norm-referenced standardised tests indicated the opposite (Wilson *et al*., 2009). Loh *et al*. (2009) obtained similar findings in a study conducted among Australian children, as the questionnaire does not differentiate the ADHD symptoms.

Relating to advantages of the DCD-Q, positive results were obtained from a study done by Green *et al*. (2005). The researchers concluded that parents could identify DCD if no other developmental problems were present. An additional advantage of the questionnaire is that children might be identified before they enter school. This would thus prevent secondary impairments associated with DCD (Missiuna *et al*., 2006), such as physical health problems due to lower activity levels (Tsiotra *et al*., 2009), social problems, emotional problems (withdrawal or exclusion from peers), as well as academic problems (difficulties with tracing, writing and learning) (Wilmut *et al*., 2007). The DCD-Q was revised to improve the ability to identify children with motor difficulties and is now known as the DCDQ'07 (Wilson *et al*., 2007). Changes included lowering the age range to children between the ages of five and seven years, modifying the items to ensure a better understanding of the activity and developing a new scoring method (Wilson *et al*., 2009). According to Wilson *et al.* (2009), the validity of the DCDQ'07 was also found to be good. Although the DCDQ'07 was developed originally in Canada, cross-cultural adaptations of this questionnaire have been made and similar results were obtained as those in Canada (Prado *et al*., 2009).

Although there are a few advantages, the independent use of questionnaires by researchers is not recommended (Junaid *et al*., 2000; Schoemaker *et al*., 2003). Schoemaker *et al*. (2003) are of the opinion that it is more beneficial to identify all the children with potential

DCD, even if some children present false positives. Using a norm-referenced standardised test after the screening process will correct the false positive diagnoses. They argue that it is ethically more responsible to over-identify children than to fail to identify the children who need interventions (Schoemaker *et al*., 2003).

PURPOSE OF THE STUDY

The aim of the study was to examine the convergent validity of the classification of motor difficulties by Kinderkineticists-in-training using the MABC-2 Test and the classification of motor difficulties by the parents of the participants using the DCDQ'07, in order to determine if parents possess the competency to identify Grade 1-learners with DCD at home. The DCDQ'07, used in the current study, has only had limited testing on South African children.

METHODOLOGY

Study design

This comparative study made use of quantitative data. The study involved 1 testing procedure by means of the Movement Assessment Battery for Children-2 (MABC-2 Test) in order to identify DCD among Grade 1-learners (N=410). The participants were tested at their schools during the Life Orientation classes by Kinderkineticists-in-training who had been trained to

use the instrument. Each Kinderkineticist-in-training was responsible for 1 subtest in order to have consistency across the study. In addition, a parent of each participant completed the DCDQ'07.

The next step was to compare the specificity and the sensitivity of the 2 measuring instruments. According to Ellinoudis *et al*. (2009), *specificity* refers to the ability of the parents using the DCDQ'07 to identify correctly children with no motor difficulties (green zone), as identified by the MABC-2 Test. *Sensitivity* refers to the ability of the parents, using the DCDQ'07, to identify correctly children with moderate (amber zone) and severe (red zone) motor problems (Ellinoudis *et al*., 2009). The results of the MABC-2 Test scores were compared to the results of the DCDQ'07 in order to determine the convergent validity between the 2 measuring instruments and to establish the competency of parents to identify DCD in children at home, thereby aiding professionals in early identification.

Participants

Initially 13 schools in the Bloemfontein area were targeted to take part in the research project, but only 7 schools eventually agreed to participate. Thus, the study made use of an availability sample. The Department of Basic Education of the Free State Province, as well as the principal of each school granted permission for the research to be conducted on the school premises during the Life Orientation class periods. Approval had been obtained from the Ethics Committee of the Faculty of Health Sciences, University of the Free State (ECUFS57/2012). The participants were treated in accordance with the ethical guidelines outlined by the Ethics Committee of the Faculty of Health Sciences. The parents/legal guardians of the participants completed an informed consent form for each child participating in this study. In addition, the children signed an assent form.

Recruitment was targeted at children with and without DCD via the 7 participating schools who had permission to take part in the study (inclusion criteria). Exclusion criteria included a child in the age group outside the expected range (younger than 5 and older than 8 years), parental permission not obtained, the informed consent form not fully completed, or parents indicating that they would be relocating during the study. Children who were absent during the testing procedure were also excluded due to incomplete testing. Additionally, the Diagnostic and Statistical Manual of Mental Disorders, 5th edition (DSM-5), (APA, 2013) was used to exclude children who had associated symptoms according to the criteria for DCD as stated in the DSM-5. Children with motor difficulties should not meet criterion C (disturbance is not due to a general medical condition, for example, cerebral palsy, hemiplegia, or muscular dystrophy and does not meet criteria for a Pervasive Developmental Disorder), or criterion D (if mental retardation is present, the motor difficulties are in excess of those usually associated with it). None of the children met the criteria and, therefore, all of them were included for further data analysis.

Measuring instruments

Movement Assessment Battery for Children-2 (MABC-2 Test)

According to Henderson *et al*. (2007), the MABC-2 Test requires children to perform a series of motor tasks in a specified manner. In addition to age-related norms, the test also provides

qualitative information on how children should approach and perform the tasks. The MABC- 2 Test is used to assess the motor proficiency levels of the subject and to diagnose DCD in children. The first assessment component of this test battery contains 24 items organised into 3 sets of 8 tasks. Each set is designed to use with children of a different age band. For the current study, age band 1 and age band 2 were used.

The 8 tasks are grouped under 3 headings, namely manual dexterity (MD), balance (B) and aiming and catching (AC) (Henderson *et al*., 2007). Age-adjusted standard scores and percentiles are provided, as well as a total test score for each of the 3 components of the test. The total test score can be interpreted in terms of a "traffic light" system. The green zone indicates performance in a normal range (>15th percentile), while the amber zone indicates that a child is at risk and needs to be carefully monitored (5th to 15th percentile). The red zone is an indication of definite motor impairment ($\leq$5th percentile). Thus, high standard scores on the MABC-2 Test represent good performance. The MABC-2 Test is a valid and reliable tool to use with a reliability coefficient for the total test scores of 0.80 (Henderson *et al*., 2007).

DCD Questionnaire '07 (DCDQ'07)

The DCDQ'07 is a brief questionnaire intended for parents to screen for DCD in children between 5 and 15 years of age (Wilson & Crawford, 2007; Loh *et al.*, 2009). The questionnaire consists of 15 items divided into 3 different categories (Wilson & Crawford, 2007). According to Wilson and Crawford (2007), the first category is "control during movement" and contains items relating to motor control while either the child or an object is in motion. The second category refers to "fine motor and handwriting" and the third category relates to "general coordination". The parent, on a scale rating from 1 to 5, rates a child's performance on each item. A rating of '1' indicates "not at all like your child", whereas a '5' indicates "extremely like your child" (Wilson *et al*., 2007). The ratings are calculated to provide a total score. The interpretation of the total score, as well as the cut-off scores, differs for the 3 different age groups specified. The DCDQ'07 is a valid and reliable tool to use with a reliability coefficient of 0.89 (Wilson *et al*., 2009).

Analysis of data

Microsoft Excel was used to capture the data from both the MABC-2 Test and the DCDQ'07 electronically. A statistician using the Statistical Package for the Social Sciences (SPSS) for Windows (SPSS version 16.0), performed the data analysis. In order to determine the convergent validity of the classification of motor problems (no motor difficulties or motor difficulties), of the MABC-2 Test and the classification of motor difficulties by the parents of the participants using the DCDQ'07, the kappa (k-) coefficient was used. This coefficient provides information with regard to the convergent validity between the 2 measuring instruments. The higher the coefficient (whether it is a negative or a positive value), the greater the convergent validity between the 2 measuring instruments.

A decision was made in an arbitrary way to assign a code 1 for the group identified with motor difficulties and a code 2 for no motor difficulties. This was done as the DCDQ'07 has only a "yes" or a "no" option and thus, the MABC-2 Test was adapted to 2 categories, namely the green zone (no motor difficulties) and the amber zone (at risk) and red zone (severe difficulties) grouped together for motor difficulties presented. Further analysis was done on these 2 categories only. Whether the correlation coefficient is a positive or a negative value can be ignored due to the codes that have been chosen in an arbitrary way. A negative correlation only indicates that the average of the group with code 2 is lower than that of the group with code 1, while a positive correlation indicates the opposite.

The practical importance of the results was also investigated. As standard of practical significance, the effect size was calculated. Effect sizes (r) were calculated to determine the practical significance of the results according to Cohen (1988), by dividing the differences in the mean by the largest standard deviation of the test results. For the interpretation of practical significance, the following guideline values need to be used when the effect size is interpreted, namely r= 0.1 is a small effect; r= 0.3 a medium effect; and r= 0.5 a large effect (Steyn, 1999). A probability level of $p<0.05$ or less was taken to indicate statistical significance.

RESULTS

Table 1 indicates the frequency distribution of the participants according to gender and race. Children (N=410) between the ages of 5 and 8 years took part in the study. The study consisted of boys (n=184) and girls (n=226), as well as an ethnic group distribution of Caucasian (n=273) and Black (n=137).

The mean age for the children was 6 years and 7 months with a standard deviation of 0.4. The minimum age was 5 years and 8 months and the maximum age was 8 years. The majority of the participants consisted of Caucasian children (66.6%), with a greater representation of girls (55.1%) than boys (44.9%) for the whole group. The gender distribution is more or less equal between the 2 ethnic groups.

*TABLE 1***.** **DISTRIBUTION OF PARTICIPANTS FOR GENDER AND RACE**

Gender	Race		Total
	Caucasian	Black	
Boys	128 (46.9%)	56 (40.9%)	184 (44.9%)
Girls	145 (53.1%)	81 (59.1%)	226 (55.1%)
Total	273 (66.6%)	137 (33.4%)	410 (100.0%)

Table 2 presents the convergent validity between the classifications of motor difficulties by means of the MABC-2 Test and the identification of motor difficulties by the parents using the DCDQ'07 for the total group, the 2 gender and 2 race groups (Caucasian and Black) independently. Finally, the convergent validity between the 2 measuring instruments with regard to Caucasian boys and girls, as well as Black boys and girls was established.

Specificity of MABC-2 Test and parent-completed DCDQ'07

The specificity, between the MABC-2 Test and the parent-completed DCDQ'07 (Table 2), was 91% for the total group.

TABLE 2. **CONVERGENT VALIDITY BETWEEN MABC-2 TEST AND DCDQ'07**

T0TAL GROUP				**Caucasian children**				**Black children**			
	MABC-2				MABC-2				MABC-2		
DCD	MD	NMD	Total	DCD	MD	NMD	Total	DCD	MD	NMD	Total
MD	12 (23.1%)	32	44	MD	6 (21%)	16	22	MD	6 (25%)	16	22
NMD	40	324 (91.0%)	364	NMD	22	227 (93%)	249	NMD	18	97 (86%)	115
Total	52	356	408	Total	28	243	271	Total	24	113	137
k-coefficient= 0.151, p=0.002 Effect size (r)= 0.151 (small)				k-coefficient = 0.164, p=0.006 Effect size (r)= 0.165 (small)				k-coefficient= 0.112, p=0.189 Effect size (r)= 0.112 (small)			

BOYS				**GIRLS**			
	MABC-2				MABC-2		
DCD	MD	NMD	Total	DCD	MD	NMD	Total
MD	10 (32.3%)	12	22	MD	6 (21%)	16	22
NMD	21	139 (92.1%)	160	NMD	22	227 (93%)	249
Total	31	151	182	Total	28	243	271
k-coefficient= 0.275, p=0.000 Effect size (r)= 0.280 (medium)				k-coefficient= 0.002, p=0.973 Effect size (r)= 0.001 (small)			
Caucasian Boys				**Caucasian Girls**			
	MABC-2				MABC-2		
DCD	MD	NMD	Total	DCD	MD	NMD	Total
MD	5 (31.3%)	5	10	MD	1 (8.3%)	11	12
NMD	11	105 (95.5%)	116	NMD	11	122 (91.7%)	133
Total	16	110	126	Total	12	133	145
k-coefficient= 0.318, p=0.000 Effect size (r)= 0.329 (medium)				k-coefficient= 0.001, p=0.994 Effect size (r)= 0.001 (small)			

Black Boys				Black Girls			
	MABC-2				MABC-2		
DCD	MD	NMD	Total	DCD	MD	NMD	Total
MD	1 (8.3%)	11	12	MD	1 (11.1%)	9	10
NMD	11	122 (91.7%)	133	NMD	8	63 (87.5%)	71
Total	12	133	145	Total	9	72	81
k-coefficient= 0.174, p=0.189 Effect size (r)= 0.175 (small)				k-coefficient= 0.013, p=0.905 Effect size (r)= 0.013 (small)			

MD= Motor difficulties NMD= No Motor difficulties DCD= DCDQ'07 MABC= MABC-2 Test

Similar findings with regard to a high specificity were established for boys (92%) and girls (90%). The specificity for Caucasian children (93%) was higher than for Black children (86%) and higher for Caucasian boys (96%) than for Black boys (83%). The results for the girls also indicated a higher specificity for the Caucasian girls (92%) than for the Black girls (88%).

Sensitivity of MABC-2 Test and parent-completed DCDQ'07

The sensitivity for the total group (Table 2) was 23%, indicating that the parents could not identify the children with motor problems. With regard to the boys, a higher sensitivity (32%) was established than for their female counterparts (10%). The results indicate similar findings comparing the Caucasian children (21%) with the Black children (25%). It is interesting to note that a higher sensitivity was found for the Caucasian boys (31%) and the Black boys (33%) than for the Caucasian girls (8%) and the Black girls (11%).

Convergent validity of MABC-2 Test and parent-completed DCDQ'07

The calculated k-coefficient of 0.151 is on the 1% significance level and provides a small effect size, which means that the findings were of insignificant practical importance (Table 2). There was, however, a significant difference (p=0.002). The results indicate that there was only a 15% convergent validity between the 2 measuring instruments after correcting for chance for the *total group*.

The results for the *boys* indicate that the calculated k-coefficient of 0.275 is on the 1% level providing a medium effect size. This implies that the findings were of average practical importance with a significant difference (p=0.000). The convergent validity was only 28%. In contrast, for the *girls* a much lower k-coefficient of 0.002 was found, which is not significant on the 5% level, and no significant difference occurred (p=0.973). The calculated k- coefficient for the *Caucasian children* was 0.164 with a significant difference (p=0.006). Although the significance is on the 1% level, it provides a small effect size, which means that the findings were of insignificant practical importance. In contrast, the convergent validity in the case of the *Black children* was 16%, which is not significant on the 5% level and indicates a k-coefficient of 0.112 with no significant difference (p=0.189).

The calculated k-coefficient of 0.318 for *Caucasian boys* was on the 1% level and provides a medium effect size, which reveals that the findings were of average practical importance. In this case, the k-coefficient indicates that there was a 32% convergent validity between the 2 measuring instruments after correcting for chance and indicated a significant difference (p=0.000). These results provide evidence that the convergent validity of these 2 measuring instruments was reasonably high for Caucasian boys. For the *Black boys*, the results indicate that the k-coefficient of 0.174 was not significant on the 5% level and, therefore, no significant difference occurred (p=0.189). Furthermore, the results of the girls indicate that the k-coefficient of 0.001 for the *Caucasian girls* and the k-coefficient of 0.013 for the *Black girls* were not significant on the 5% level for both groups. No significant differences were observed for the *Caucasian girls* (p=0.994) or for the *Black girls* (p=0.905). It could be concluded that there was also no significant convergent validity between the 2 measuring instruments (MABC-2 Test and the DCDQ'07) for the various variables, except for *Caucasian boys*.

DISCUSSION

The purpose of the study was to examine the convergent validity of the classification of motor difficulties by Kinderkineticists-in-training using the MABC-2 Test and the classification of motor difficulties by the parents of the participants using the DCDQ'07 in

order to determine if parents have the competency to identify Grade 1-learners with DCD at home. This convergent validity was determined for the total group (N=410) and for the genders and the specific race groups (Caucasian and Black) independently. Finally, the convergent validity between the two measuring instruments with regard to Caucasian boys and girls as well as Black boys and girls was established.

The research set out to provide possible answers to the questions pertaining to the specificity and sensitivity of the DCDQ'07 when completed by parents – an area in which only a limited amount of research has been done (Schoemaker *et al*., 2006). No other studies have been conducted to compare the specificity and sensitivity between the parent-completed DCDQ'07 and the MABC-2 Test in order to determine the convergent validity of the identification of DCD among different ethnic groups (Caucasian and Black), thus no comparisons could be made with previous research.

Although the design of this study used the revised DCDQ'07, previous findings on the original DCD-Q are discussed also, but are limited to the findings for the total group. As seen in Table 2, the current study indicates that the convergent validities for the boys and girls were 32% and 10% respectively, indicating that the boys had a convergent validity of average practical importance and the girls showed no convergent validity at all. According to the original DCD-Q, gender did not influence the scores in older age groups (nine to 14 years and six months) (Wilson *et al*., 2000; Schoemaker *et al*., 2006). However, for the younger age groups (four to eight years), boys scored significantly lower than girls. Nakai *et al*. (2011) and Rivard *et al*. (2014) reported similar findings, where the researchers found significant differences between gender groups with the girls constantly scoring higher than the boys. In contrast, a study on Brazilian children (N=30) concluded that there were no significant differences in the total scores of the different genders when the original DCD-Q was used (Prado *et al*., 2009). In order to correct this discrepancy, separate impairment scores by age and gender were developed for the revised DCDQ'07.

Specificity of MABC-2 Test and parent-completed DCDQ'07 for the total group

The study succeeded in showing that the parents could identify a large percentage of children without motor difficulties, a specificity of 91% (324 out of 356), when using the age-related cut-off scores for the three adjusted age groups. Similar to the results of this study, the majority of previous research reported a high specificity on the original DCD-Q. The current study correlates with the findings of Wilson *et al.* (2000), who reported an even higher specificity of 95% (20 out of 21) and with that of Schoemaker *et al.* (2006), who tested a clinic-referred sample (N=110) and found an 84% (42 out of 50) specificity on the original DCD-Q. Schoemaker *et al.* (2006) also conducted a study on a population-based sample (N=322) and found a higher specificity of 89% (218 out of 246). Prado *et al.* (2009) adapted the DCD-Q for Brazilian children and found an 87% specificity, which correlates with the current study.

However, several authors have proposed lower specificity on the original DCD-Q. Wilson *et al.* (2000) reported lower specificity on the original DCD-Q (71%) than the current study for the DCDQ'07. Civetta and Hillier (2008) indicated that the specificity of the original DCD-Q on a total of 460 children in Australia was only 62%. Tseng *et al.* (2010) indicated a lower

specificity of 54% on the Chinese version of the original DCD-Q, while Green *et al.* (2005) found an even lower specificity of only 19%.

With reference to the revised DCDQ'07, Wilson *et al.* (2009) established a specificity of 71% with the DCDQ'07, while Parmar *et al.* (2014) established a higher specificity of 92%. In another recent study, Caravale *et al.* (2014) adapted the DCDQ'07 for Italian children (N=26) and found a specificity of 96%. It is clear that conflicting results still occur and, therefore, it is recommended that the DCDQ'07 should be adapted to each country in order to adjust for cultural differences; in addition, larger samples should be tested.

Sensitivity of MABC-2 Test and parent-completed DCDQ'07 for the total group

The current study indicated that a large percentage of children with motor difficulties could not be identified by the parents, showing a sensitivity of only 23% (Table 2), which correlates with Loh *et al.* (2009), who reported that the original DCD-Q had a low sensitivity in detecting children with mild motor difficulties. Schoemaker *et al.* (2006) also found a low sensitivity of 29% (22 out of 76) with regard to a population-based sample (N=322).

However, several authors have proposed higher sensitivity when using the original DCD-Q. Civetta and Hillier (2008) established 72% sensitivity for the original DCD-Q, while Tseng *et al.* (2010) found similar results of 73%. Wilson *et al.* (2000) found that the original DCD-Q had a high sensitivity of 86%. This correlates with research conducted by Schoemaker *et al.* (2006), who established a sensitivity of 82% (49 out of 60) on the clinic-referred sample (N=110), and with the research reported by Prado *et al.* (2009) with the Brazilian version, where a sensitivity of 87% was reported. The highest sensitivity was reported by Green *et al.* (2005), who found an even higher sensitivity of 93% among a sample of 98 children.

With reference to the revised DCDQ'07, Wilson *et al.* (2009) differ from the current study and found a higher sensitivity of 85%, as did Caravale *et al.* (2014), who established 88% sensitivity. However, a recent study conducted by Parmar *et al.* (2014) found a very low sensitivity of 21% on the DCDQ'07, which correlates with the findings of this study. Similar to the results with regard to specificity, the results for sensitivity differ between various authors since conflicting results occur. It is recommended, therefore, that more research should be conducted on this topic. In addition, the researchers propose that the norms might be adapted in order to address the specific needs of each country.

The k-coefficient for the present study (0.151) differs from Schoemaker *et al*. (2006), who established a k-coefficient of 0.65 for the clinic-referred sample and 0.21 for the population-based sample, while Green *et al*. (2005) found a lower k-coefficient of 0.14.

Convergent validity of MABC-2 Test and parent-completed DCDQ'07 for total group

An overall analysis of the convergent validity between the MABC-2 Test and the DCDQ'07 indicates that the DCDQ'07 completed by the parents has a convergent validity of 15% (8 out of 52) with the MABC-2 Test in identifying children with motor difficulties and, therefore, the convergent validity is low (small effect). These results correlate with research conducted by Wilson *et al*. (2000), who established 27% convergent validity (4 out of 15) and Crawford *et al*. (2001), who demonstrated that the questionnaire did not identify children with motor

difficulties as frequently as a therapist. These results also correlate with the study by Parmar *et al.* (2014), who also used the revised DCDQ'07 and performed an ROC analysis, concluding that the convergent validity between the MABC-2 Test and the DCDQ'07 was low.

The findings of Schoemaker *et al*. (2006) are in contrast with the current study, with a convergent validity of 83% (91 out of 110), for the clinic-referred sample. For the population- based sample, the convergent validity was lower, but at 75% (240 out of 322), still higher than in the current study.

CONCLUSIONS

The aim of the study was to examine the convergent validity of the classification of motor difficulties by Kinderkineticists-in-training using the MABC-2 Test and the classification of motor difficulties by the parents of the participants using the DCDQ'07, in order to determine if parents possess the competency to identify Grade-1 children with DCD at home. To our knowledge, this is the first study in South Africa to assess the competency of the parents to use the DCDQ'07 to identify correctly children with motor difficulties.

This study showed only a 15% convergent validity between the MABC-2 Test and the DCDQ'07. The ability of parents in the Bloemfontein area, Free State Province, to use the DCDQ'07 to identify correctly children with motor difficulties was found to be low. Thus, the DCDQ'07 is useful to screen children without DCD, although the purpose of a screening tool is to identify children with a specific condition. The findings of the current study demonstrate the need for further research in identifying efficient and effective assessment screening tools for parents to help professionals in the early identification of motor difficulties. It is clear from the research that a screening tool alone rarely will identify all children with DCD and that the DCDQ'07 may not be the best screening tool for parents to identify DCD in children at home. In addition, it is recommended that specific norms should be established for South African children.

LIMITATIONS AND RECOMMENDATIONS

This study had some limitations. A comparison between the DCDQ'07 and the MABC-2 Checklist, which can be completed by the parents also, could have been conducted to determine which screening questionnaire yields the best results. The parents who took part in the current study were not taught specifically how to complete the DCDQ'07. The large number of parents may have affected the reliability of the scores according to the DCDQ'07. Furthermore, since this was a population-based sample, criterion B of the diagnostic criteria for DCD, which states that the academic performance of the children should also be considered (APA, 2013), was not used. Moreover, it should be recognised that the current study recruited children from the Bloemfontein metropolitan area only. Hence, a replication of this study in different provinces and regions in South Africa is recommended to provide more robust results that can be generalised. Other limitations are the use of Canadian norms in a South African population, and the Canadian item development including specific sports, which may not be applicable to South African children.

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INTERRELATIONSHIPS BETWEEN VISUAL-MOTOR INTEGRATION, VISUAL PERCEPTION, MOTOR COORDINATION AND OBJECT CONTROL SKILLS OF GRADE 1-LEARNERS: NW-CHILD STUDY

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ABSTRACT

The aim of this study was to determine the interrelationship of visual-motor integration, visual perception and motor coordination with object control skills in Grade 1-learners in the North-West Province of South Africa. This study is based on only the baseline data of a longitudinal study (NW-CHILD study) in progress. The Grade 1-learners (N=806) had a mean age of 6.84±0.39 years. The Developmental Test of Visual-Motor Integration (4th ed.) (VMI), was used to evaluate visual skills, while the Test of Gross Motor Development-2 evaluated six object control skills. There was a statistical significant ($p\leq0.01$) association between VMI, two object control skills and total score for object control skills. Visual perception had the highest correlation with all the object control skills where a statistically significant ($p\leq0.05$) association with five object control skills and the total score was obtained. Motor coordination had small but significant correlations with two object control skills. Understanding the influence that VMI, visual perception and motor coordination have on ball handling skills should enable practitioners to address them appropriately during the early years.

Key words: Visual-motor integration; Visual perception; Motor coordination; Object control skills.

INTRODUCTION

Visual-motor integration refers to the action of merging visual information with fine motor skills and is important in the acquisition of perceptual-motor skills such as handwriting, keyboarding and the throwing or catching of a ball (Avi-Itzhak & Obler, 2008). Fine motor skills require rigorous movements of the hands and fingers and depend on hand-eye coordination to perform a task successfully (Beery & Buktenica, 1997; Baard, 1998). Deficiencies in these skills could contribute to problems pertaining to academic skills, participation in school activities and self-concept (Ercan *et al*., 2011).

Visual-motor integration involves not only hand-eye coordination, but also visual perceptual skills (Pereira *et al*., 2011). Visual-motor integration is referred to also as changing visual perception into a motor output. According to Weil and Amundson (1994), visual-motor integration is supported by skills, such as visual perception, psychomotor speed and hand-eye coordination. Wilson and Falkel (2004) further indicate that good hand-eye coordination is necessary for sport, such as basketball, volleyball and baseball, and they highlight the importance of foot-eye coordination, to get into the best position to perform a hand-eye

coordination task. Barnhardt *et al*. (2005) found in their study of eight- to 13-year-old American children (N=37), that the child who had poor visual-motor integration skills made significantly more errors in skills with a visual perceptual component. According to Tepeli (2013), visual perception and motor performance are linked closely. Bonifacci (2004), in his study of 141 Brazilian children, aged 6 to 10 years, found a significant difference in visual-motor integration skills between children with low and high gross motor skills.

Visual perception is a complex process involved in both object identification and locating of an object in space (Jeannerod, 2006). This system is also intricately connected to the action systems of the body (Jeannerod, 2006), and relies on the candour of the posterior parietal cortex and cortical networks produced from the occipital lobe (Lieberman, 1984; Ganis *et al*., 2004). Visual perception comprises of more than one concept and includes object/form perception and spatial perception. Object/Form perception can be broken down further into form consistency, visual closure and figure-ground perception (Schneck, 2010). These concepts are all relevant in a situation where object control skills are used.

Form consistency is the ability to recognise objects in different environments, sizes and positions; figure-ground perception includes being able to define objects from the fore- or background; visual closure is the ability to recognise a shape or form when incomplete; and spatial perception is the ability to locate an object in space (Schneck, 2010). These perceptual abilities will enable learners to locate a ball in space for instance, and be able to accurately catch or throw it back to a team mate in a sporting situation.

According to Wilson and Falkel (2004), visual perception in sport involves a player being able to focus on the ball, whilst in addition keeping track of the different placing's of his team mates and of the opposition. Researchers (Smith *et al*., 2003; Cinelli, 2006; Gabbard, 2008), claim that visual perception is the ability to perceive if an environment is safe enough, which then leads to perception, which is necessary to discern actions. Wilson and McKenzie (1998) found that problems with visual components were associated with problems in motor coordination. A study by Tepeli (2013) on Turkish children (N=322), ranging from 54 to 59 months, found that the visual perception skills of these children improved as their gross motor skills (locomotor and object control skills) improved and vice versa. This researcher also found that visual perception could be a predictor of good execution of object control skills (Tepeli, 2013).

Motor coordination describes the process of obtaining visual information and responding with the correct coordination of the mind and body (Maneval, 1999), while Cheatum and Hammond (2000) refer to motor coordination as the ability to coordinate body movement and vision. Visual-motor skills are inadmissible to success in school and social life (Maneval, 1999), and plays a crucial role in activities where hand-eye and foot-eye coordination is important, especially in sport such as rugby, hockey, netball and soccer, where a ball has to be kicked, hit or caught, while paying attention to an opponent (Cheatum & Hammond, 2000). Wilson and Falkel (2004) indicated that visual-motor integration is one of the most basic components to be linked to sport performance. They also indicated that if the eyes were unable to move quickly and efficiently, a child would not be able to perform well in sport (Wilson & Falkel, 2004). They emphasised the importance of the integration of visual perception and motor coordination to be able to perform unforeseen movements on the sport

field.

Coetzee and Du Plessis (2013) in their study of 816 children (419 boys and 397 girls) in the North-West Province of South Africa, found significant correlations between visual-motor integration and visual perception, and visual-motor integration and motor coordination. There were also significant correlations between visual perception and motor coordination (Coetzee & Du Plessis, 2013). It could be concluded that because of the inter-relationship of these skills, any problems that could arise in one of these skills could affect the others adversely. Sortor and Kulp (2003) reported that problems with visual-motor integration could be affected by difficulties experienced in visual perception and/or motor skills.

Manipulation skills, or object control skills as referred to in this study, include those skills that apply force or receive force, such as when throwing, catching, striking, dribbling and kicking a ball (Gallahue & Donnelly, 2003). Jeannerod (1996) and Winnick (2011) found that locating an object in space was dependent on more complex visual skills, such as figure- ground perception, the perception of distance and form constancy. According to Cheatum and Hammond (2000), Pienaar (2014) and Willoughby and Polatajko (1995), the development and/or improvement of motor skills that involve coordination (hand-eye and foot-eye) are dependent on the visual systems functioning effectively and on good eye-muscle control.

Deficits in visual perception will contribute to locating an object inaccurately, which would affect goal-directed movement negatively. Generally, movements could become less skilful due to inadequate visual information (Jeannerod, 1988). However, Bonifacci (2004) indicates that poor performance in motor skills is not necessarily associated with problems in visual perceptual abilities. Tsai *et al*. (2008) support this finding by claiming that visual perception shortcomings and motor tasks may be task-specific and do not necessarily have an interrelationship.

From the literature, it seems that visual-motor integration, visual perception and motor coordination may play an important role in object control skills, sporting activities and everyday life. If problems arise in any of these three areas, it could have a debilitating effect on future sport participation and life skills.

PURPOSE OF RESEARCH

Little research has been reported on the effect that poor visual-motor integration, visual perception and motor coordination abilities could have on object control skills. Investigating these relationships will shed light on the potential role that these skills could have on perceptual-motor ability and sport performance of children, and may contribute to a better understanding among teachers of how to improve these skills in the different areas in South Africa.

METHODOLOGY

Research design

This study is based on a longitudinal study, Child-Health-Integrated-Learning and Development study (NW-CHILD study), which spans over a period of 6 years (2010-2016)

and include 3 sequential measurements throughout. For the current research, only the baseline data of this project, collected in 2010, were used. Therefore, for this particular research, a one-time cross-sectional design was applied.

Participants

The target population for this study was Grade 1 learners in the North-West Province of South Africa. The total number of participants identified for the study was 880 Grade 1 learners. The research group was selected by means of a stratified random sample in conjunction with the Statistical Consultation Services of the North-West University. To determine the research group, a list of names of schools in the North-West Province was obtained from the Department of Basic Education of the North-West Province. This list of schools was grouped in 4 educational districts, each representing 12 to 22 regions, with approximately 20 schools (minimum 12, maximum 47) per region. Regions and schools were selected randomly with regard to population density and school status (Quintile 1, that is schools from poor economic sectors, to Quintile 5 schools from affluent economic sectors).

Boys and girls in Grade 1 were selected randomly from each school. A total of 20 schools were involved in the study, from 4 districts with a minimum of 40 children per school and with an even gender distribution. The total group consisted of 806 learners (413 boys; 393 girls) with a mean age of 6.78±0.39 years. During the entire study, 13 (1.5%) parents/legal guardians did not consent to participation, whereas 35 (4.0%) of the selected participants were absent from school on the day of testing or had to be excluded because of incorrect ages provided by the schools.

The principals of the various identified schools were asked for permission to collect the data during school hours. If the number of learners in the school allowed it, 60 Grade 1-learners were selected. These learners received informed consent forms that had to be completed by their parents/legal guardians. This was done to ensure that informed consent would be granted by the parents/legal guardians for a minimum of 40 learners that needed to be tested at each school, so that the study would have sufficient the power/impact. Only the learners, whose parents consented, participated.

Ethical considerations

Ethical approval was obtained from the Ethics Committee of the North-West University, Potchefstroom Campus (No. NWU-0070-09-A1), and permission was granted by the Department of Basic Education of the North-West Province to conduct the study. At a formal meeting with each principal, the aim and protocol of the study were explained and permission was asked to collect the data during school hours. The purpose of this study was explained verbally to all the participants, and any questions about the procedures answered. Trained interpreters were used to convey the instructions of the evaluators to the children, if English was not their first language.

Measuring instruments

Developmental Test of Visual-Motor Integration (4th ed.) Test battery (VMI-4)

The VMI-4 (Beery & Buktenica, 1997) consists of the visual-motor integration test and 2 subtests which include visual perception and motor coordination. The aim of the VMI-4 is to identify children who need special assistance, by means of early detection. The complete 27- item-VMI-4 test can be administered individually or in groups, it takes about 10 to 15 minutes to complete, and can be used from pre-school children to adults. The visual-motor integration subtest consists of a list of consecutive geometrical shapes, which have to be drawn with a pencil on paper. Ten to 15 minutes is allowed to complete the test or it is stopped after 3 consecutive mistakes. The visual perception subtest requires matching shapes with each other and takes 3 minutes to complete or until 3 consecutive mistakes are made. The last subtest, motor coordination, involves completing dots in a shape and takes 5 minutes to complete.

The criteria for awarding marks in the VMI-4 are as follows: a “0” is awarded for wrong figures; and a “1” is awarded for the correct figures. The data is captured under the 3 categories: visual-motor integration; visual perception; and motor coordination. The raw score is converted to a standard score and then to a percentile. Using the standard score, children can be grouped into 5 different classes, ranging from very high (133 to 160), high (118 to 132), average (83 to 117), low (68 to 82) to very low (40 to 67). The VMI-4 was developed to measure the extent to which an individual can integrate his visual and motor capabilities. The VMI-4 subtests have a validity of 0.92, 0.91 and 0.89 respectively (Beery & Buktenica, 1997).

Test of Gross-Motor Development-2 Test battery (TGMD-2)

The TGMD-2 test is designed to test the gross motor functioning of children from 3 to 10 years old (Ulrich, 2000). This test consists of 12 motor skills and is divided into 2 subtests, namely locomotor (run, hop, gallop, leap, horizontal jump and slide) and object control (striking a stationary ball, stationary dribble, catch, kick, overhand throw and underhand roll), skills. For the purpose of this study, only the object control subtest was used.

Each of these fundamental motor skills has 3 to 5 performance criteria. For example, there are 5 performance criteria for striking a stationary ball: 1) “Dominant hand grips bat above non- dominant hand”; 2) “Non-preferred side of the body faces the imaginary tossed ball with feet parallel"; 3) "Hip and shoulder rotation during swing"; 4) "Transfers body weight to front foot"; and 5) "Bat contacts ball". Marks were allocated as follows: "1" point was awarded for each correct execution of the specific skills; and "0" for a failed attempt. The child was allowed 2 attempts at each skill. A visual demonstration was given for each skill before it was tested, however, the component that was assessed for every skill, was not mentioned to the child.

The score for each of the 2 attempts for each performance criteria was added together. To obtain the skill score, all the total scores for each criterion were added together. At the end of the object control subtest, the 6 skill scores were added up to determine the subtest raw score of 48 points. The child's age, gender and raw score were used to calculate the standard score and percentile rank. The descriptive categories of the TGMD-2's manual are: excellent (subtest standard score 17 to 20); good (15 to 16); above average (13 to 14); average (8 to
12); below average (6 to 7); poor (4 to 5); and very poor (1 to 3). A standard score between 1 and 3 is considered, therefore, as very low mastery of the object control skill, while a score of 17 to 20 is considered as very good mastery of the object control skill. Content-description,

criterion-prediction and construct-identification validity support the use of the TGMD-2 to identify children who are significantly behind their peers in gross motor development with a reported coefficient alpha of 0.90. Furthermore, the test has been found to be reliable in all demographic subgroups with quotients reaching or exceeding 0.87 (Ulrich, 2000).

Statistical analysis

The STATISTICA software package (StatSoft, 2013) was employed for the analysis of the data. Firstly, descriptive statistics, (mean [M], standard deviations [SD], minimum and maximum values), of each variable was calculated. Secondly, Spearman rank order correlation was used to determine the correlations among visual-motor integration, visual perception, motor coordination, striking a stationary ball, stationary dribble, catching, kicking, underhand rolling, overhand throwing and the object control skills total. The strength of the correlation was set at $r\approx0.1$ indicating a small effect, $r\approx0.3$ a medium effect and $r\approx0.5$ a large effect (Cohen, 1988). Lastly, ANOVA was used to determine the relationship between visual-motor integration, visual perception, and motor coordination and object control skills. The statistical significance level was set at $p\leq0.05$.

RESULTS

A total of 413 boys and 393 girls were identified as participants (N=806) for this study. The group had a mean age of 6.84±0.39 years with the boys having a slightly higher mean age of 6.87±0.39 years compared to the girls (6.81±0.38 years). Table 1 displays the age composition of the study population by gender.

TABLE 1. **AGE OF PARTICIPANTS BY GENDER**

Study population	N	M±SD	Minimum	Maximum
Boys	413	6.87±0.39	6.00	7.67

Girls	393	6.81±0.38	6.00	7.67
Total	806	6.84±0.39	6.00	7.67

N= Number of participants M= Mean SD= Standard Deviation

Table 2 displays the results of the mean scores obtained in each test variable for the 806 participants. The mean scores vary from high to low in the various object control skills, where the participants obtained the highest mean score in striking a stationary ball (6.78±1.84). The participants also received high mean scores in visual-motor integration (91.46±13.78), motor coordination (92.88±14.72) and a slightly lower mean score in visual perception (79.12±22.96).

TABLE 2. **DESCRIPTIVE DATA FOR VISUAL-MOTOR INTEGRATION, VISUAL PERCEPTION, MOTOR COORDINATION AND OBJECT CONTROL SKILLS OF PARTICIPANTS** (N=806)

Variables	M±SD	Min	Max
Object control skills			
Striking a stationary ball	6.78±1.84	0.00	10.00
Stationary dribble	4.17±2.42	0.00	8.00
Catch	4.70±1.12	2.00	8.00
Kick	6.07±1.42	1.00	8.00
Overhand throwing	2.88±2.34	0.00	8.00
Underhand rolling	4.36±1.87	0.00	8.00
Object control skills: Total	7.10±2.16	1.00	14.00
VMI-4			
Visual-motor integration	91.46±13.78	0.00	155.00
Visual perception	79.12±22.96	0.00	139.00
Motor coordination	92.88±14.72	0.00	140.00

N= Number of participants; M= Mean; SD= Standard Deviation; Min= Minimum Max= Maximum VMI-4= Visual-Motor Integration (4th ed.)

TABLE 3. **CORRELATION BETWEEN VISUAL-MOTOR INTEGRATION, VISUAL PERCEPTION, MOTOR COORDINATION AND OBJECT CONTROL SKILLS**

Variable	VMI SS	VP SS	MC SS
Striking a stationary ball	0.06	0.12*	0.07
Stationary dribble	0.14*	0.14*	0.14*
Catch	0.11*	0.16*	0.06
Kick	-0.06	-0.12*	0.02
Overhand throw	0.09*	0.14*	0.00
Underhand rolling	0.17*	0.19*	0.09*

Object control skills: TOTAL	0.21*	0.27#	0.18*

VMI= Visual-motor integration; VP= Visual perception; MC= Motor coordination; SS= Standard Score Significance accepted: r≥0.1*= small r≥0.3#= medium

A Spearman rank order correlation was used to determine the correlations among visual-motor integration, visual perception, motor coordination and the 6 object control skills. The latter includes striking a stationary ball, stationary dribble, catch, kick, underhand roll and overhand throw. The results in Table 3 indicate small significant correlations (r≥0.1) between visual-motor integration and 4 of the object control skills (stationary dribble, catching, overhand throwing, underhand rolling), including the object control total. Visual perception also showed a small correlation (r≥0.1) with all 6 of the object control skills (striking a stationary ball, stationary dribble, catching, kicking, overhand throwing, underhand rolling), while a correlation with medium practical significance (r≥0.3) was found between visual perception and the object control skills total.

TABLE 4. **INTERACTION BETWEEN VISUAL-MOTOR INTEGRATION, VISUAL PERCEPTION, MOTOR COORDINATION CLASSES AND OBJECT CONTROL SKILLS**

Variables	Class 2	Class 3	Class 4	Class 5	MSE	p
Visual-motor integration						
Striking a stationary ball	6.64	6.87	6.62	6.14	3.38	0.082
Stationary dribble	4.52	4.36(4)	3.54	3.43	5.75	≤0.001*
Catch	5.04	4.73	4.50	4.74	1.24	0.060
Kick	5.76	6.09	6.12	5.83	2.02	0.475
Overhand throw	3.12	2.95	2.68	2.34	5.45	0.291
Underhand rolling	5.36(5)	4.44	4.09	3.49	3.42	≤0.001*
Object control skills total	7.92(5)	7.23(4)	6.45	6.23	4.52	≤0.001*
Visual perception						
Striking a stationary ball	7.05	7.02(5)	6.78	6.41	3.34	≤0.001*
Stationary dribble	4.47	4.57(4, 5)	4.00	3.80	5.77	≤0.001*
Catch	5.05	4.84(5)	4.65	4.50	1.23	≤0.001*
Kick	5.66	5.96	6.16	6.19	2.01	0.057
Overhand throw	3.89(5)	3.17(5)	2.74	2.49	5.34	≤0.001*
Underhand rolling	4.74	4.78(4, 5)	4.25	3.88	3.37	≤0.001*
Object control skills TOTAL	8.11(5)	7.57(4, 5)	6.99(5)	6.29	4.36	≤0.001*
Motor coordination						
Striking a stationary ball	6.73	6.83	6.63	6.43	3.39	0.434
Stationary dribble	3.60	4.33(4)	3.47	3.57	5.77	≤0.001*
Catch	4.67	4.70	4.78	4.43	1.25	0.381
Kick	5.40	6.13	5.99	5.69	2.01	0.052

Overhand throw	3.67	2.84	3.13	2.67	5.45	0.335
Underhand rolling	$4.60^{(4, 5)}$	$4.45^{(4, 5)}$	4.07	3.74	3.47	0.033*
Object control skills total	$7.33^{(4, 5)}$	$7.19^{(4, 5)}$	6.63	6.17	4.59	≤0.003*

Class 2= *High* Class 3= *Average* Class 4= *Low* Class 5= *Very Low*

* For statistical purposes, scores of learners in Class 1 (very high) and Class 2 were combined due to small number in both classes; Significance level= p≤0.05; MSE= Mean Square Error; Superscript= Significant difference between classes

Motor coordination (Table 3) only shows small significant (r≥0.1) correlations with 2 of the object control skills (stationary dribble, underhand rolling and the object control total), as well as the object control skill total, while no correlations were found between striking a

stationary ball, catching, kicking and overhand throw (r≤0.1).

In Table 4, the results of an ANOVA are presented, which indicate the relationship between values obtained and classified into different visual-motor integration-, visual perception- and motor coordination classes with the different object control skills. Visual-motor integration scores were grouped into 5 different classes, ranging from very high (Class 1= 133 to 160), high (Class 2= 118 to 132,), average (Class 3= 83 to 117), low (Class 4= 68 to 82) to very low (Class 5= 40 to 67).

For the purposes of this study, the children in Class 1 and Class 2 were combined due to the small number of children who were classified in Class 1. Furthermore, the results reveal that there was a statistically significant (p≤0.01) association between visual-motor integration and stationary dribble, underhand rolling and the object control skills total. In stationary dribble, a tendency of a decline of the visual-motor integration mean scores was seen from Class 2 to Class 5. It seems that as the visual-motor integration values decreased so did the stationary dribble values. The same tendency was found in the underhand rolling and the object control total scores. In all these skills and the object control skills total there were statistically significant associations (p≤0.05) between VMI that ranged from high (Class 2) to very low (Class 5).

Visual perception had a statistically significant association (p≤0.05) with striking a stationary ball, stationary dribble, catch, overhand throw, underhand rolling and the object control skills total. A tendency of higher mean scores for visual perception was found for the participants that were classified in Class 2 (high), with a linear decline to Class 5 (very low), that could be observed in striking a stationary ball, catch, overhand throw and the object control skills total. Only the mean scores for underhand rolling and stationary dribble had a slight incline from Class 2 to Class 3.

In motor coordination, underhand rolling and the object control skills total scores showed a consistent decline from Class 2 to Class 5. Stationary dribble had a slight increase from Class 2 to Class 3 and then continued declining from then on. There was a statistically significant association (p≤0.05) between the VMI categories in these 3 skills: visual-motor integration; visual perception; and motor coordination (Table 4).

DISCUSSION

The aim of this study was to determine the interrelationship between visual-motor integration, visual perception, motor coordination and object control skills.

The results indicate that there were small to medium correlations between visual-motor integration, visual perception, motor coordination and the various object control skills. Visual perception showed the strongest relationship within all the object control skills and the object control skills total compared to visual-motor integration and motor coordination. The study reported by Tepeli (2013) on 54- to 59-months-old Turkish children in Konya, investigated the relationship between gross motor skills and visual perception. The findings of Tepeli (2013) are in agreement with our findings as this researcher indicates that visual perception was a strong predictor of object control skills.

When the possible interaction between visual-motor integration, visual perception and motor coordination with the different object control skills was investigated, visual perception indicated the most significant effect ($p \leq 0.05$) in five of the six object control skills. These findings are supported by the results of Wilson and Mackenzie (1998), which showed that children who experience problems with visual perception would have problems in motor tasks. Oktay and Unutkan (2003) also support this finding by stating that visual perception is crucial for tasks, such as throwing and grasping. The positive relationship that was found between visual perception and successfully performed object control skills make sense, based on the assumption that a motor action can only be carried out by perceiving sensory information correctly and reacting accordingly. Thus, the task is accomplished by using body and brain together.

As mentioned previously, visual perception includes form consistency, visual closure and figure-ground perception (Schneck, 2010). Form consistency is necessary to recognise an approaching ball of whichever size or position, and figure-ground perception enables the child in any given game situation to be able to focus on an oncoming ball or team mate. Visual closure and spatial perception is needed so that during a game a child can track a ball thrown by a team mate accurately or to position him-/herself to be available for the opportunity to catch a ball (Schneck, 2010).

Kicking was the only skill, which had a negative interaction with visual perception, although the relationship was not significant. According to Bonifacci (2004) in his study on 6 to 10 year old children (N=144), poor performance in motor skills was not necessarily associated with poor visual perceptual skills. Tsai *et al*. (2008) also found motor tasks and visual perception to be specific and not to necessarily have a relationship. Other studies that made similar comparisons are, however, limited to compare with the current findings.

Visual-motor integration only had significant correlations with four of the six object control skills, as well as the object control skills total. On examination of the possible interaction between visual-motor integration and object control skills, only stationary dribble, underhand rolling and the object control skills total were significantly better in Class 2 (high) and Class 3 (average), compared to Class 4 (low) and 5 (very low). This finding supports that of Wilson and Falkel (2004), who reported that visual-motor integration is one of the components that can be linked easily to performance in sport, furthermore that good coordination between the hands and eyes are important for sport, such as basketball, volleyball and baseball. Bonifacci (2004) in his study of Brazilian children (N=141), aged 6 to 10 years, found a significant difference in visual-motor integration skills between children with low and high gross motor skills.

Motor coordination correlated with two of the six object control skills and when the possible interaction was studied, motor coordination only had significant relationships with stationary dribble, underhand rolling and the object control skills total. The children had higher mean scores in Class 2 (high) and 3 (average), compared to Class 4 (low) and 5 (very low). Motor coordination showed a very small correlation with object control skills in this study. This is in contrast with previous research, which found that motor coordination is crucial in activities where hand-eye and foot-eye coordination is important (Cheatum & Hammond, 2000). Possible reasons for this could be that the motor coordination task in this study relies on hand

control and more on fine motor skills in comparison to the object control skills that rely on the use of gross motor skills during this study.

PRACTICAL APPLICATION

The value of this article is that it sheds light on the potential role that these skills could have on the perceptual-motor ability and sport performance of children, and may contribute to a better understanding among coaches of how to improve these skills in the Grade 1-learners in South Africa. Children with poor ball handling skills can be assessed for visual perception and then supported by interventions that address these possible deficiencies.

CONCLUSION

While conducting the current research, it became clear that it is the first of its kind, investigating the interrelationship between the VMI-4 and TGMD-2. Due to the possible and various effects that visual skills may have on sport skills, it seemed important to investigate the effect that these skills might have on basic ball skills, which could later have an effect on sport skills. It was difficult to find literature specifically with regard to a normal South African population to support or disprove our findings. A possible reason for this could be the fact that the VMI-4 test battery was not designed originally to be compared to gross motor skills, but rather with test batteries focusing on visual skills and fine motor skills. However, there were small correlations between components that required hand control, such as dribbling, rolling and striking a stationary ball and motor coordination, but there were little to no relationship with components, which did not require it, such as kicking and catching. Important information with regard to visual-motor integration, visual perception, motor coordination and object control skills has been reported herewith. The findings of this study indicate that there were limited interactions between visual-motor integration, motor coordination and object control skills. However, there were various relationships between visual perception and object control skills.

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RELATIONSHIPS BETWEEN PHYSICAL AND BIOMECHANICAL PARAMETERS AND GOLF DRIVE PERFORMANCE: A FIELD-BASED STUDY

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ABSTRACT

A proficient golf swing is composed of a sequence of highly complex biomechanical movements and requires precisely timed and coordinated body movements to achieve great distance and accuracy. The aim of the current study was to identify the key physiological and biomechanical variables that relate to golf drive performance. Eighteen golfers (handicap 11±6 strokes, playing experience 18±15 years), volunteered to take part in the study. Drive distance and accuracy were measured directly. Balance was assessed using a modified stork test and hand-eye coordination was assessed using a 3D maze. Average balance duration of both legs (r= 0.563; p=0.015), left leg (r= 0.620; p=0.006) and right leg (r= 0.488; p=0.044) were all significantly correlated to drive distance. Hand-eye coordination was significantly negatively correlated to total drive distance (r=-0.600 p=0.008), but was not associated significantly with the centre of hit between the clubface and ball. Several parameters were found to have significant relationships to golf drive distance in a group of amateur golfers. Therefore, training regimes could include tasks that aim to improve hand-eye coordination and balance.

Key words: Co-ordination; Balance; Biomechanics; Golf; Performance.

INTRODUCTION

The game of golf requires players to strike a golf ball so that it travels long distances towards a small target (Hume *et al*., 2005). A proficient golf swing is composed of a sequence of highly complex biomechanical and coordinated body movements (Knight, 2004; Jagacinski *et al*., 2009; Wells *et al*., 2009; Keogh & Hume, 2012), which affect the distance and accuracy of the flight of the ball. To drive the golf ball effectively, a golfer needs to adopt various body positions throughout the swing, which requires well-developed postural control and balance (Smith, 2010). Sell *et al*. (2007) has suggested that finer balance, flexibility and coordination are all required to perform an effective golf swing.

It should be emphasised that the overall purpose of the golf swing is to develop a maximal amount of kinetic energy that is transferred directly to the golf ball (Nesbit & Serrano, 2005). Indeed, the displacement of the golf ball (from tee to eventual point of rest), has been shown to be a direct function of linear club head velocity (Penner, 2003; Hume *et al*., 2005). Despite this, it should be noted that increasing the club head velocity alone might not result in an

overall increase in the distance achieved during ball flight, because other factors, such as spin, may affect the accuracy and distance of the shot (Hume *et al*., 2005).

A biomechanical analysis by Chu *et al*. (2010) emphasised the importance of trunk rotation, delayed action of the left arm and wrist uncocking during the swing. The role of the latter contributors to the kinetic energy, used in the swing and their relation to ball velocity, confirm the importance of training regimes that aim to improve the muscle groups involved in the action of the golf swing (Chu *et al*., 2010). Zheng *et al.* (2008) found that golfers who are more skilled had greater ranges of motion at the top of the backswing. Additionally, these skilled golfers were able to maintain a higher X-factor value (separation of shoulders relative to the hips), and had a greater left elbow flexion through the downswing phase (Zheng *et al.*, 2008). These two swing optimisations may be efficient strategies used to transfer optimal energy during the downswing. Chu *et al*. (2010) showed that the forces developed in the golf swing begin from the contact of the feet with the ground, and progress through the legs, trunk and finally the arms. The role of the lower limbs in the development of power appears particularly important in the backswing position (Chu *et al*., 2010).

Weight transfer from one leg to another is as vital in achieving a successful golf swing (Hume *et al*., 2005) as a golfer's ability to control his/her balance (Smith, 2010). Additionally, a change in the position of the centre of gravity will allow a golfer to compensate for the position and momentum of the golf club (Burden *et al*., 1998). Proper balance in turn, is needed to create a stable base around which the pelvic and shoulder girdles can rotate (Gordon *et al*., 2009), allowing maximum momentum to be transferred to the golf ball (Thompson *et al*., 2007; Worsfold *et al*., 2008; Jagacinski *et al*., 2009).

Eye-hand-club coordination, the ability of a golfer to control their hand position, as well as the club, by using information received from the eyes, is also an important aspect of golf driving skill. Experienced golfers may be able to compensate for errors that may occur in the swing (Bradshaw *et al*., 2009). The ability to control the movements and position of the hands, based on information received from the eyes, is a highly complex task (Natarajan & Malliga, 2011).

Unlike other sport where hand-eye coordination is an important performance related component, the hand-eye coordination necessary for golf is compounded by properties, such as the length and loft of the golf club. The control of the club is vital to the outcome of the shot (Knight, 2004), and the position at which the clubface strikes the ball is known to be a major contributor to the resulting flight of the ball (Neal *et al*., 2007). Although the effect of club type has been shown to alter the coordinative strategies of trained golfers' body segments (Shan *et al*., 2011), the interaction between the club itself and the hand-eye coordination of golfers has never been assessed.

Golfers are subject to the antagonistic effects of the autonomic nervous system, whereby the parasympathetic nervous system, which reduces heart rate, may allow a higher level of focus. However, increasing the level of sympathetic nervous system activity may improve the force of muscle contractions. Neumann and Thomas (2009) showed that experienced golfers had a lower heart rate than novice players just prior to putting, which indicates that experienced

players are able to calm themselves before attempting the shot. The effect of an elevated heart rate on the performance of a golfer's drive shot is unclear.

PURPOSE OF STUDY

Despite anecdotal suggestions that hand-eye coordination is vitally important to a successful golf swing, quantified empirical proof that assesses the magnitude of the contribution that this variable makes to a successful golf swing is largely lacking. Therefore, there is a need to quantify the effects of balance and hand-eye coordination on the direct outcomes of the golf swing. It is hypothesised that the balance duration of a golfer should have a direct relationship to the drive distance achieved. Furthermore, it is expected that other physiological contributors, such as hand-eye coordination, and autonomic state (as measured by heart rate), will affect the drive performance of golfers. The results of this study may provide valuable insight into variables related to drive performance, which then might be incorporated into existing training programmes in order to improve golf drive performance.

MATERIAL AND METHODS

Participants

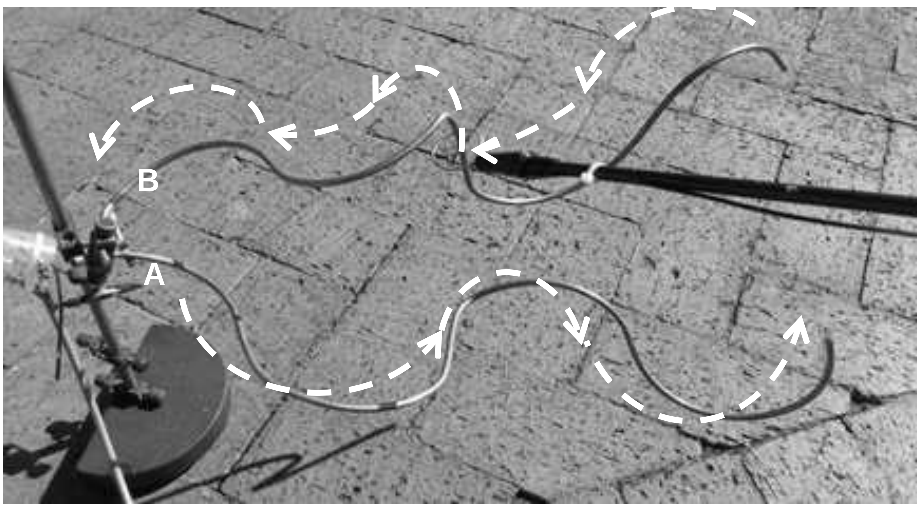
Eighteen right handed golfers (handicap 11±6 strokes, playing experience 18±15 years) with an average age of 36±13 years volunteered to take part in the study. The 18 golfers had an average height of 176.9±7.1 centimetres, body mass of 84.1±14.3 kilograms, lean body mass of 79.6±8.2% and heart rate of 74.4±15.1 beats/ minute. They had all played golf regularly in the past year (87±33 rounds a year) and were injury free at the time of testing. Ethical clearance was obtained from the Human Research Ethics Committee (Medical) of the University of the Witwatersrand (M110424) and written informed consent was obtained from all of the participants. All of the participants were recruited from a local practise facility.

Experimental procedures

In addition to participants being allowed to warm-up in their own accustomed manner, they were required to hit 5 practice balls under experimental conditions. Participants aimed their shots at a target, which was placed 260m from the tee at 1 end of a flat, grass, outdoor driving range. The accuracy was determined from the distance perpendicular from the tee-target axis to the resting position of the ball. Drive distances were determined from the intersection between the tee-target axis and the final position of the golf ball. The distance was measured, by using a retractable measuring line, as the distance between the final resting position of the ball and the tee. The participants hit 10 golf balls: 5 with their own driver and another 5 with a standard club. A standardised club was used to eliminate any manufacturer specific technologies that may have been present. All shots were hit from a standard tee. The centre of the clubface was identified by measuring the width and height. A piece of contact sensitive paper (70x35 mm) was placed over this position, so that the centres of the contact sheet and clubface overlapped, and was used to quantify the centeredness of hit for every shot.

Hand-eye coordination

Hand-eye coordination was determined by using a custom-made 3-dimensional maze constructed from brass tubing, which required a golfer to move a club through 360 degrees in both the horizontal and vertical planes (Figure 1). A wire loop fitted to the end of a driver's shaft was used to complete the task. Golfers were instructed to complete the maze in the shortest possible time, making as few contacts between the driver shaft and maze as possible. Errors (contacts between club and maze) and timing were tracked through an electric circuit that closed when an error was made. The maze circuit was connected to a Powerlab 26T system (ADInstruments, Bella Vista, New South Wales, Australia), which allowed errors and maze duration to be recorded.



Participants were required to move the loop at the end of a driver shaft from starting point (A) to end point (B) as fast as possible without touching the maze itself. Dashed arrows identify the intended path.

FIGURE 1. **THREE-DIMENSIONAL MAZE TO DETERMINE HAND-EYE COORDINATION**

Participants were instructed to hold the club shaft with the same 2-handed grip (baseball, interlock or overlap), that they would use when holding a golf club. They were allowed to rotate their hands and move their arms and upper bodies while keeping their feet stationary, which would mimic the hand and arm movements that occur during the swing. Participants were instructed to complete the task as quickly as possible without incurring any errors. The maze was designed to test the rotational control of the wrists in both the horizontal and vertical planes while in a forwards and backwards motion, and was placed in a similar location to where golfer's would need to make corrections to their swing in order to strike the ball effectually.

Balance tests

Two balance tests were performed. The first test required the participants to raise one of their legs to create a 90-degree angle at both the knee and hip joints (Modified Stork test)

(Hungerford *et al.*, 2007) with their hands positioned on their hips. The second test required

the participants to stand on each of their legs in the same manner as before. Once the participants were in this position, they were instructed to close their eyes. The time that each participant could maintain balance was recorded to the nearest second for a maximum of 60 seconds. Each test lasted until balance had to be re-established by removing hands from hips, downward movement of raised leg or excessive lateral trunk movement. The time was recorded for each leg and the mean duration for both legs was calculated. Participants wore their golf shoes during the balance procedures.

Lean mass percentage was determined by bio-impedance using BodyStat 1500 (BodyStat, Douglas, Isle of Man, United Kingdom). Prior to the participants' warm-up, their sedentary ***heart rate*** was recorded after a seated period of 5 minutes using a heart rate monitor (Polar S610, Polar Electro Oy, Kempele, Finland).

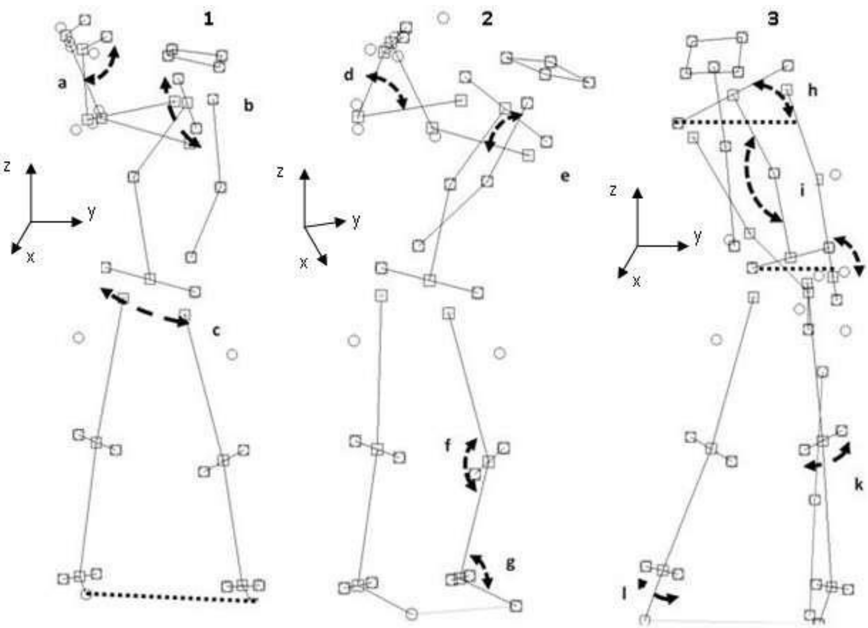
Biomechanical analysis

Biomechanical data was record at 250Hz using 6 Optitrack 250e (Natural Point Inc., Corvallis, Oregon, USA), high-speed cameras to capture all of the swings. All biomechanical data was analysed in MatLab 7 (Mathworks, Natick, Massachusetts, USA). The calibrated capture volume for trails was approximately $\pm 32m^3$, with volume calibration only being accepted when calibration residuals were less than 1mm. The *x*-axis corresponded to the anterior/posterior direction, *y*-axis to the medial/lateral direction, and *z*-axis to the superior/ inferior direction.

Retro-reflective markers (10mm diameter) were placed on the following anatomical landmarks: jugular notch; xiphoid process; 7^{th} cervical vertebra; 10^{th} thoracic vertebra; and sacrum. Additional retro-reflective markers were placed bilaterally on the first finger, acromion process, mid-point on the lateral aspect of the calf and thigh, anterior superior iliac spine (ASIS), first toe and heel. Furthermore, markers were placed both medially and laterally on the wrists, elbows, ankles and knees, and 4 markers on the head. Additional markers were placed on the rubber tee and the club head, to determine when ball contact was made. Virtual markers for joint centres were found using mathematics similar to the Plugin Gait model (based on Kadaba *et al.*, 1990 and Gutierrez *et al.*, 2003). Joint centres for elbows, wrists, knees and ankles were defined as the midpoints of the respective lateral and medial markers.

The calculated biomechanical variables are shown in Figure 2. Shoulder and pelvis rotations were the angles created by translating the shoulder vector line (right shoulder marker to left shoulder marker), and the pelvic vector line (Right ASIS marker to left ASIS marker), to the midpoint of the vector line established by the toe markers in the address position on the *xy*-plane. X-Factor was the difference between the shoulder rotation and pelvis rotation. All rotation values were calculated to the vector line created by the toe markers in the address position indicating the intended direction of the golf shot. Positive rotation values indicated rotations to the right of the intended target line. The leading arm angle was calculated as the difference between an established thorax vector (thorax tilt as defined by the vector from right shoulder marker to left shoulder marker), and the upper left arm vector (left shoulder marker to the virtual marker at the centre of the left elbow joint), where 180 degrees indicated complete abduction of the left arm and 0 degrees indicated complete adduction.

Shoulders and pelvis elevations were calculated using the vector lines transposed on to the *yz-* plane and compared to the toe vector line in the address position. The lateral bend was the angle created by 2 planes in the trunk. The first plane was established between the mid-shoulder point, xiphoid process and the 10th thoracic vertebra. The lower trunk plane was established between the xiphoid process, mid-anterior superior iliac spines and the sacral marker. A positive angle indicated flexion of the upper thorax towards the lower trunk segment. Knee and ankle rotation angles were calculated using the vector lines from the middle of the joint to the lateral marker, and compared to the vector created from the toes in the address position.



Position **1** *&* **2**= Full backswing; *Position* **3**= Ball contact - Full backswing (frame before downswing started), ball contact and end of follow through (when club shaft is stationary behind shoulders)

X-axis: Anterior/posterior direction; *Y-axis*: Medial/lateral direction; *Z-axis*: Superior/inferior direction

a= Wrist flexion angle	**b** & **c**= Shoulder & pelvis rotations	**d**= Elbow flexion angle
e= Leading arm angle	**f**= Knee flexion angle	**g**= Ankle flexion angle
h & **j**= Shoulders & pelvis elevations	**i**= Lateral bend	**k** & **l**= Knee & ankle rotation angles

FIGURE 2. **DEFINITIONS OF BIOMECHANICAL ANGLES**

The biomechanical analysis was performed at 3 stages (Figure 2): full backswing (the frame before the downswing started - downward movement of the club head); ball contact; and at the end of the follow through (when the club shaft was stationary behind the shoulders). The contribution of the arms in the follow-through position was found to have a minimal effect on the outcome of the shot. The variables related to the arms were excluded, as they were likely to indicate the dissipation of energy. The nature of the golf swing and the method of outdoor data acquisition resulted in the loss of kinematic data (markers not being visible), and thus a subsample of 7 participants with complete data sets underwent biomechanical analysis.

Statistical analysis

All data was tested for normality in Prism 5 (GraphPad, San Diego, California, USA) and presented as a mean±the standard deviation unless stated otherwise. Either Spearman's or Pearson's correlations were performed based on the distribution of the variables using the automated algorithms of Prism 5 (GraphPad, San Diego, California, USA), to determine the existence of any relationships with a significance level of $p<0.05$. A student's t-test was used to determine if there was any difference in the distance achieved when using each of the clubs.

RESULTS

No difference was found between the standard and the participant's club (p=0.820). All correlations were assessed with the average distance being calculated based on the combined distance values recorded for the standard and participants' clubs. The average drive distance over 10 shots was 227±37m with an accuracy of 21±6m from the intended target. The accuracy of the drive was not correlated significantly with any of the physiological or biomechanical variables measured in this study. The average distance from the club centre to the ball strike position was 2±7mm. The time taken to complete the hand-eye coordination task was 29±13 seconds with an average of 66±14 errors. The resulting score for the hand-eye coordination task was 2.7±1.1 errors/ seconds. The values for the balance test with eyes open were right leg 52.7±16.0 seconds and left leg 51.1±15.6 seconds (average balance 51.9±15.4 seconds). The values for the balance test with eyes closed were right leg 15±15 seconds and left leg 15±15 seconds (average balance 15±15 seconds).

TABLE 1. **CORRELATION COEFFICIENT VALUES OF DRIVE DISTANCE AND VARIABLES (n=18)**

Variables	r	p-values
Lean body mass (%) #	0.599	0.004*
Average balance (seconds) #	0.563	0.005*
Right leg (seconds) #	0.620	0.015*
Left leg (seconds) #	0.480	0.002*
Hand-eye coordination (errors/second) †	-0.600	0.024*
Handicap (strokes) †	-0.577	0.012*
Resting heart rate (beats/minute) †	-0.102	0.688
Playing experience (years) †	0.012	0.962
Golf rounds per year †	0.276	0.268

Spearman's correlation coefficient † Pearson's correlation coefficient
* Significance= p<0.05 Mean drive distance= 226.76±36.61m

Drive distance was correlated negatively to the hand-eye coordination task (Table 1) and correlated positively to balance as defined by an average duration for the balance task, both legs with eyes open. The correlation between the balance task duration for the left leg was greater than that of the right leg. No significant correlation was found between drive distance and balance with eyes closed. The distance from ball contact to the club's 'sweet spot' and the hand-eye coordination task was not significantly correlated (r=-0.428; p=0.07, Pearson's correlation). Further correlations of drive distance are recorded in Table 1, which shows the relationship between lower handicaps and greater drive distances.

TABLE 2. **BIOMECHANICAL VARIABLES AND PEARSON'S CORRELATION COEFFICIENT VALUES OF BALANCE AND DRIVE DISTANCE**

Variables	**Backswing**		**Contact**		**Follow through**	
(Angles in degrees)	n	Mean±SD	n	Mean±SD	n	Mean±SD
Left wrist	5	80.0±40.1	6	15.9±7.1		n.a.
Right wrist	4	79.6±63.6	6	34.6±13.8		n.a.
Leading arm	7	170.2±1.8	7	167.3±1.1		n.a.
Left elbow	6	139.9±15.1	7	139.3±37.5		n.a.
Right elbow	7	72.4±7.1	7	161.1±10.9		n.a.
Lateral bend	6	43.7±7.5	7	11.7±2.5		n.a.
Hip rotation	7	66.4±35.2	7	23.3±12.4	7	-86.9±10.9
Shoulder rotation	7	100.4±26.8	7	14.1±11.5	5	-57.8±11.3
X-Factor	7	34.0±32.3	7	-9.2±7.6	5	29.1±4.6
Pelvis elevation	7	-0.2±2.5	7	15.3±1.9	7	15.0±1.5
Shoulder elevation	7	-1.6±1.3	7	4.2±3.09	5	1.4±1.5
Left knee	7	135.5±9.4	7	166.2±7.1	7	165.3±11.9
Right knee	7	160.9±3.4	7	155.5±6.3	7	156.5±8.1
Left ankle	6	99.1±9.5	7	77.5±7.7	7	80.6±7.7
Right ankle	6	83.2±4.9	6	71.5±12.2	7	41.0±12.6
Left knee rotation	7	8.0±9.1	7	30.4±6.6	7	42.8±5.8
Right knee rotation	7	142.8±4.8	7	159.0±16.3†	7	40.9±18.5
Left ankle rotation	7	34.7±12.2	7	35.7±4.1	7	32.9±12.3*
Right ankle rotation	7	138.4±17.0	7	145.7±4.2	7	166.1±15.0*

* Correlated to drive distance (p<0.05) † Correlated to right leg balance, eyes closed (p<0.05)
n.a. = Arms at follow through not analysed

Note: Sample size (N=18) varies depending on visibility of reflective markers, which dictated ability to analyse data. Full backswing (frame before downswing started), ball contact and end of follow through (when club shaft was stationary behind the shoulders).

A subsample of the participants underwent full body biomechanical analysis. These variables are represented in Table 2. This sample (5 to 7 participants) was affected by the visibility of the markers at each phase of the swing. The only correlation (Pearson's) between the biomechanical variables at the contact position and the physiological variables was right knee rotation angle and balance duration with closed eyes (r= 0.835; p<0.05). Right ankle rotation angle (r= 0.781; p<0.05) and left ankle rotation angle (r= 0.769; p<0.05), at the follow- through position were shown to have a significant correlation with drive distance.

DISCUSSION

The results presented in this study indicate that the ability to achieve longer drive distances may be related to a high level of motor control, as shown during the hand-eye coordination task, as well as a level of balance control. Variables that correlated positively with drive distance included: balance time; and percentage of lean mass. Other variables that correlated with drive distance included the hand-eye coordination task and handicap. The accuracy of the drive did not correlate significantly with any of the physiological or biomechanical variables measured in this study. It is likely that accuracy is determined by other aspects of the golfer's anthropometry, physiology and human biomechanics and is likely to be related to variables more closely associated with the contact of the clubface with the golf ball. As expected and previously shown by Fradkin *et al*. (2004), the negative correlation between handicaps and total drive distance (club head velocity in the case of Fradkin *et al*., 2004), was present in this study.

The important contribution that the ability to balance plays in golf performance, as shown in the data, agrees with studies done on older golfers (Tsang & Hui-Chan, 2010), and highly proficient golfers (Sell *et al*., 2007). Data from the present study shows that drive distance was affected by the ability to balance. Balance in golfers was investigated previously by Sell *et al*. (2007) and their results indicate that balance was correlated to drive distance, however, the drive distances were self-reported by their participants and not directly measured. Wells *et al*. (2009) failed to show a correlation between balance and drive distance, however, non- dominant leg balance was shown to correlate with the number of greens hit in regulation. It is likely that left leg balance is more important in achieving greater drive distances as the follow-through phase of the golf swing results in a larger proportion of the total body mass being supported by the left leg (Wells *et al*., 2009). Better balance in the follow-through phase may allow for a greater transfer of kinetic energy to the ball during the swing phase, with the body's momentum being compensated for during the follow-through. The correlation with the right leg could indicate the weight transfer during the backswing phase where the body mass is shifted towards the right leg (Wells *et al*., 2009).

Sell *et al*. (2007) along with Lephart *et al*. (2007) had their subjects perform balance procedures barefoot with their eyes open and then closed. Although they made use of a different protocol to that used in the current study, they found that balance differed between golfers of various skill levels, which could be improved following a training regime. It is likely that the addition of golf shoes would be a true reflection of the ability to balance by the golfers, as they require these specifically designed shoes to play (Worsfold *et al*., 2008). Balance, in the current study, was determined while participants wore golf shoes and stood on a level patch of grass, which mimicked real golf situations. The decision to select a 60-second cut-off for balance was a limitation of this study, with a high percentage of the golfers having the test terminated at this level. Despite this, the positive correlation shown testifies to the importance of balance ability for the golf drive.

A rough indication of the players' autonomic state as recorded by their resting heart rate showed no relationship with the drive distance. It is likely that a more detailed evaluation of the physiological state is required to identify the specific or the combined parameters that contribute towards achieving a competent golf drive.

The hand-eye coordination task used here not only tested the complexities of fine motor coordination as per Natarajan and Malliga (2011), but also tested the ability to control a golf club. The negative correlation between drive distance and the hand-eye coordination task would suggest that the golfers' ability to control their hands and upper limbs would greatly affect their ability to strike the ball. It is interesting that the hand-eye coordination task did not have a significant correlation with the ball strike distance from the centre of the club or drive accuracy. However, this result may prove to be significant in an increased sample size ($p=0.07$, $N=18$) and be attributable to the advances in the designs of modern day drivers, which aim to improve ball strike by increasing the 'sweet spot' area on the clubface. Although the speed at which the test was conducted does not match the speeds of a golf shot, the test was designed to quantify the golfer's ability to manipulate the golf club as an extension of the kinetic chain, as well as the coordinative ability required to do so. It needs to be noted that whole body coordination and proprioception are likely to affect the drive distance (Knight, 2004; Neal *et al*., 2007; Keogh & Hume, 2012), which may form part of a more inclusive future study than the discrete measurements made in the present study.

When determining relationships between physiological components and the biomechanical movement, it was found that a relationship exists between the right leg balance with eyes closed and the right knee rotation-angle in the contact position. In the ball contact position of the golf swing, it is essential that the golfer maintain a functional level of balance, while still transferring a vast proportion of their body weight (Chu *et al*., 2010). The data showed that the right knee rotation-angle correlates with the right leg balance. The fact that the latter balance measurement was made with closed eyes biased the possible sensory inputs for balance towards the vestibular, mechanoreceptive and muscular sense, whilst also ensuring that balance could not be maintained for long durations. The weight shift around the knee joint could be similar, when the balance is tested, to that during the swing. The results in this study show that the relationship seems to occur at the level of the knee and not lower at the ankle joint.

In the follow-through position, the left and right ankle rotation angles correlated with the drive distance achieved, which would suggest that the rotation around the ankles is related to the shift in weight. The greatest proportion of weight would be on the left leg at the follow- through stage of the swing (Worsfold *et al*., 2009). The ankle needs to rotate in order to allow the weight shift to occur and to establish a firm base for the large rotations of the pelvic (Knight, 2004) and shoulder girdle (Gordon *et al*., 2009). The right ankle, which is not part of the major weight shift at this stage of the swing (Worsfold *et al*., 2009), would have a greater rotation value than the left ankle because of the completion of the weight transfer from the right leg at the backswing position to the left leg in the follow-through position. Although Knight (2004) suggests that an open left toe at the follow-through phase of the swing would allow for greater pelvic rotation, this relationship was not found to be present in this study. Weight shift was not measured in the current study; therefore, the relationship between ankle rotation angles and weight shift is speculative and requires further research.

Only the left ankle rotation value in the follow-through position was correlated to drive distance. This value may be related indirectly to the weight transfer occurring during the golf swing (Worsfold *et al*., 2009). The small sample of biomechanical data may exclude any relationships present in previous studies (Chu *et al*., 2010).

The large variation of handicaps, shown by golfers in the present study, facilitated the significant correlations between drive performance and balance or coordination. Future studies could exclude less experienced golfers to focus on a narrower range of handicaps for ascertaining if these relationships remain or whether other variables become more important. The limit for the balance protocol of 60 seconds could be extended until the golfer needs to regain balance, although this may then be testing the fatigue threshold of the individual legs rather than balance. Instead of a field balance test, whole body centre of gravity sway during quiet standing and during the golf swing could be quantified also. There is a need to determine the coordinative abilities of the golfer and their ability to ensure momentum transfer between the centre of the clubface and the golf ball. The coordinative abilities may not be limited to hand-eye coordination, but rather the coordination of individual body segments, coordination between the body segments, fine motor coordination, whole body coordination or the efficacy of the entire coordination system (Shan *et al*., 2011), involving the proprioceptive, somatic, vestibular and central nervous system. These coordinative aspects require further investigation to assess whether any relationships exist. Biomechanically, more studies are required to investigate the interaction between leg rotations and weight distribution throughout the golf swing.

CONCLUSION

In conclusion, several parameters related to golf drive distance were identified in a group of amateur golfers. This was done by demonstrating that the combination of the components shown in the individual variables may result in greater drive distances. Individual leg balance ability was shown to be an important contributor to a successful golf drive. Additionally, hand-eye coordination, as tested by the golfers' ability to manipulate the golf club through a three-dimensional maze, was shown to be a determinant of golf drive performance. Therefore, it may be beneficial for a golfer to include tasks that improve hand-eye coordination and balance in their practice and training regimes.

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CONSTRAINTS TO PARTICIPATION IN ORGANISED SPORT: CASE OF SENIOR UNDERGRADUATE STUDENTS AT A NEW GENERATION UNIVERSITY

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ABSTRACT

Tertiary institutions are vital settings for helping young adults gain the physiological, psychological and social benefits of participating in organised sport. This study aimed at determining the constraints that prevent students from continuing participation in organised sport at a South African university. It used a quantitative research design in which a structured questionnaire was administered to 283 senior undergraduate students based at three campuses of a university located in the Eastern Cape Province of South Africa. Exploratory factor analysis was employed in identifying six constraints, namely 'time and scheduling', 'accessibility', 'lack of partners', 'personal/psychological factors', 'socialising activities' and 'facilities'. The t-tests showed significant differences between males and females for 'lack of partners'. An Analysis of Variance confirmed significant differences for 'accessibility', 'socialising activities' and 'facilities' relative to the amount of money available for leisure.

Key words: Organised sport; Leisure constraints; Sport participation; University students.

INTRODUCTION

Worldwide there seems to be a decline in sport participation despite the considerable benefits derived from an active lifestyle. In addition to the physical, psychological and social benefits, participation in organised sport holds the benefits of regular practice and competition in an organised environment, teamwork, cooperation and loyalty. Regular physical exercise leads to healthy bones and muscles (Le Menestrel & Perkins, 2007), increases bone density and thus helps to prevent osteoporosis and improves the body's oxygen transport system and endocrine function (Sothern *et al*., 1999). In addition to the physical health benefits, is the idea that "a healthy body leads to a healthy mind" (Bailey, 2006:399). Athletes often attain higher marks and strive for more advanced academic goals than their fellow students who do not participate in sport (Nthangeni *et al*., 2009), perhaps because it is believed that sport participation can improve academic performance by increasing the flow of blood to the brain and enhancing mental alertness (Bailey, 2006).

Participation in formally organised sport also allows and encourages participants to compete on a regular basis in a well-organised and controlled environment. Furthermore, competitive sport contributes to community identity and a sense of belonging and pride (Tonts, 2005), teaches participants the value of teamwork and cooperation, encourages integration and socialisation of groups from different cultural and ethnic backgrounds, creates opportunities to negotiate and find solutions to moral clashes, and helps develop self-control, loyalty and courage (Nthangeni *et al*., 2009).

Perhaps even more important is the likelihood of continuing to enjoy the benefits into adult life, particularly if a physically active lifestyle is developed during adolescence. Unfortunately, the negative consequences of a physically inactive lifestyle in the early adult years often also continue into later life. Overweight youths often mature into obese adults and run the risk of suffering from heart disease, Type 2 diabetes and related health problems (Nam *et al*., 2009). Obesity tends to result in a vicious cycle that further discourages sport participation (Lewis & Van Puymbroeck, 2008). Because of the stigma attached to obesity, sufferers become self-conscious, have low levels of sport-participation confidence and decline any physical participation opportunities (Lewis & Van Puymbroeck, 2008).

Despite its benefits, sport participation has decreased considerably among the general population since the turn of the century, even reaching stagnation point in some countries (Lera-López & Rapún-Gárate, 2011). For example, in England sport participation fell from 48% in 1990 to 46% in 1996 and then dropped to 43% in 2002 (Lera-López & Rapún-Gárate, 2011). In Canada, only 28% of people 15 years and older participated in sport in 2005 compared with 34% in 1998 (Ifedi, 2005).

These trends are reflected also in low levels of physical activity among tertiary students. For example, in North Western Europe and the United States, 23% of students are physically inactive during their leisure time, while in developing countries (Columbia, South Africa and Venezuela), this figure has reached 44% (Haase *et al*., 2004). Both Australian and American youth show a marked decline in sport participation when moving from school to university (Leslie *et al*., 2001). Bloemhoff and Coetzee (2007) found that continued sport participation among South African students transitioning from school up to third year university level decreased from 71.3% to only 31.5%.

Tertiary institutions provide excellent opportunities to influence young people's participation in sport. Such attempts are important, since students constitute a significant group of young adults whose behaviour and attitudes, as future opinion leaders and policy makers, can shape societal principles and norms (Leslie *et al*., 2001). Furthermore, it is argued that the behaviour adopted by university students may shape future health habits (Adedoyin *et al.*, 2014). This age group was thus, the focus of the current research.

PURPOSE OF STUDY

The aim of the research was to determine what prevents students who have participated in organised sport at school from continuing to do so at university. A few South African studies (Bloemhoff & Coetzee, 2007; Nthangeni *et al*., 2009), investigated the barriers to student participation in sport, but none focused on participation in *formally organised* sport. The current research aimed to help fill this void.

LITERATURE REVIEW AND CONCEPTUAL CONTEXT

Most research in leisure constraints and barriers to sport participation appear to be based on the research of Crawford *et al*. (1991). These authors identified three primary sources of leisure constraints, namely intrapersonal, interpersonal and structural.

Intrapersonal constraints

Intrapersonal barriers involve individual psychological states and attributes, such as stress and depression (Crawford *et al*., 1991), feeling too tired, or lacking the confidence to participate in activities (Park, 2004), personality factors and attitudes (Godbey *et al*., 2010), lack of interest or enjoyment, or even lack of information about where to participate or who to contact to learn the skills in order to participate (Godbey *et al*., 2010). This appears to imply that constraints inherent to the individual could serve as the primary barriers preventing participation in leisure activities, such as sport.

Interpersonal constraints

Interpersonal constraints are influenced by social relationships (Öcal, 2014), and result from the interaction among persons who participate in an activity (Crawford *et al*., 1991). Examples of interpersonal constraints include dependence on "important others [such as] family members, partner, friends" (Masmanidis *et al*., 2009:151), and difficulty in finding co- participants to interact with in a sport or other activities (Tsai & Coleman, 2007).

Since intrapersonal constraints "pre-exist in the individual, before s/he is faced with the possibility of participating in recreational activities" (Masmanidis *et al*., 2009:151), it seems logical to assume that attempts will be made to overcome interpersonal constraints once intrapersonal constraints have been successfully negotiated. For example, if someone has access to a number of co-participants, this might not result in overcoming a lack of confidence or developing an interest in playing sport.

Structural constraints

Structural constraints are aspects that interfere in the interaction between leisure preference and actual participation (Hurd & Forrester, 2006), for example, lack of time, lack of finances, and facility-related problems such as accessibility (Crawford *et al*., 1991; Alexandris & Carroll, 1997; Mirsafian, 2014). Accessibility might be hindered by the inappropriate location of an activity (Tsai & Coleman, 2007). Examples of structural constraints of a financial nature are a lack of money for membership fees, equipment and travel (Tsai & Coleman, 2007). Time, a further structural constraint, might also affect the level and frequency of sport participation. It is argued that obligations such as study, work or participation in other recreational activities (Tsai & Coleman, 2007), could leave the individual with little time for playing sport. On the other hand, those who participate in sport do not have more time available than those who do not; it depends on the priority given to participation (Yusof & Shah, 2007). Participating in sport is a conscious decision to prioritise the use of one's time.

Hierarchical arrangement of constraints

Previous research (Crawford *et al*., 1991) maintains that constraints to leisure participation are experienced hierarchically. According to this theory, intrapersonal constraints form the first level of the hierarchy and are overcome often by "some combination of privilege and exercise of the human will" (Crawford *et al*., 1991:313). Interpersonal constraints, for example, trying to find a partner to co-participate in the leisure activity (Crawford *et al*., 1991), constitute the second level of constraints. Once these constraints have been overcome, structural constraints become important. Finally, after structural constraints have been negotiated successfully, participation is likely to follow (Crawford *et al.*, 1991). The findings, of more recent research by Godbey *et al*. (2010), suggest that the hierarchical model is in fact circular. This means that interpersonal, intrapersonal and structural constraints can be experienced in any order and that the first level need not be intrapersonal (Godbey *et al*., 2010*)*.

Demographic characteristics

Characteristics such as gender may also function as constraints to sport or leisure participation. According to research quoted by Adedoyin *et al*. (2014), the prevalence of physical activity is considered higher generally in males than females. The roles and responsibilities that women have in society, resulting from family commitments and cultural beliefs, are believed to limit their freedom and choices concerning leisure participation (Drakou *et al*., 2008; Mirsafian *et al*., 2014). Park (2004) found that female adolescents experienced far higher intrapersonal and total constraints than male adolescents did, while Drakou *et al*. (2008) indicate that females experience a lack of technical skills, private transportation and financial resources more than males do. No conclusive results appear to exist for studies dealing with university students.

In their study of Nigerian students, Adedoyin *et al*. (2014), found no significant difference between the physical activity levels of the two genders. Male and female students at a university in Turkey experienced significantly different constraints to leisure participation (Yetgin, 2014), with regard to a lack of knowledge about the availability of facilities, a lack of companions, friends not enjoying leisure activities and having no time for leisure activities. Mirsafian (2014) found that Iranian students' perceptions of intrapersonal, interpersonal and structural constraints differed significantly based on age, gender and level of education, while those of Hungarian students differed significantly only in the case of intrapersonal constraints. Iranian female students did not participate in sport because they experienced the impact of intrapersonal, interpersonal and structural constraints more than males, while Hungarian female students experienced higher levels of intrapersonal constraints compared with their male counterparts. Malaysian students also differed in terms of interpersonal, intrapersonal and structural constraints to sport participation. Female students experienced significantly higher structural and intrapersonal constraints than male students did (Yusof *et al*., 2007).

Other demographic characteristics such as income, education and social background might also constrain participation in sport. Having more available income to spend on sport participation, constraints, such as inaccessibility, lack of transport and finances are significantly reduced (Godbey *et al*., 2010). Individuals from low socio-economic

backgrounds may not have the financial resources to travel to participate in sport, nor to pay fees to join facilities that offer sport programmes; in addition, facilities in poorer areas tend to be overcrowded and not well maintained (Casper *et al*., 2011). The current study focused on gender because senior undergraduate students have similar levels of education and few have their own income.

EMPIRICAL CONTEXT

The university that served as the empirical setting for the study is situated in the Eastern Cape Province, one of the poorest provinces in South Africa. A large portion of the students are from rural areas within the province and make use of on-campus and off-campus accommodation. Participation in organised sport at the university decreased from 20% in 2013 to 13% in 2014 (Boukes, 2015). Ethical clearance for the study was applied for and granted by the official Ethics Committee of the university. The allocated ethics number is H 2011 BUS MRK 13.

RESEARCH METHOD

Research design

A quantitative research approach and a cross-sectional survey was adopted for the study, since the data collected from a number of cases at one time was sufficient to detect patterns of association (Bryman & Bell, 2011), and to answer the research question.

Sampling

The target population for the research comprised 13 970 students in their second, third or fourth year of study enrolled at the three campuses of the university in question. The campuses have well-developed sporting facilities and student residences. Senior students were selected because first year students might find the progression from school to university challenging, for example, adjusting to university life, particularly with regard to being flexible and making choices about their daily living patterns (Bloemhoff & Coetzee, 2007), getting to know university sport structures and being integrated into teams, which could affect their participation in sport. In addition, many of the summer sport leagues have started by the time first year students arrive on campus.

A combination of purposive and convenience sampling was used to select potential respondents. Potential participants were required to answer 2 screening questions to determine their eligibility to participate in the survey. Firstly, they had to be part of a sport team at school that competed against other schools, and secondly, they should not have participated in a sport league or competed as part of a team during the 10 months preceding the date of data collection. Four hundred (400) questionnaires were distributed proportional to the number of students per campus and 283 usable questionnaires were returned (a response rate of 65.2%). Twenty-two of the respondents did not participate in competitive sport at school and thus they were excluded from the analysis.

Questionnaire

The data was collected by means of an interviewer-administered survey and a structured questionnaire. Section A of the questionnaire required respondents to indicate how strongly they disagreed (1) or agreed (5) with 27 5-point Likert scale items that measured constraints to participation in organised sport. The items included in this section were based partly on the work of Drakou *et al*. (2008) and Bloemhoff and Coetzee (2007). Factors identified by Drakou *et al*. (2008) that influenced Greek students' leisure participation included *lack of access, lack of facilities, lack of company, lack of time, lack of knowledge, lack of interest* and a *psychological dimension*. The Cronbach's alpha coefficients associated with these factors ranged from 0.60 to 0.89. Bloemhof and Coetzee (2007) identified *study responsibilities, lack of time to participate, social responsibilities, injuries, lack of financial resources, lack of effective sport administration, lack of sport facilities, lack of knowledge about sport, and other* as factors constraining sport participation among South African university students, but did not provide the respective Cronbach's alpha coefficients.

Section B contained 5 questions that captured respondents' gender, age, available money to spend on leisure, country in which they finished their schooling and home language. A convenient sample of 50 students was chosen to pilot test the questionnaire. Based on their feedback and the preliminary data analysis, a few minor adjustments were made before the questionnaire was distributed to the main sample.

Statistical analysis

The data was captured in Microsoft Excel and analysed using Statistica Version 10. The analysis was done in 3 stages, namely a calculation of descriptive statistics, exploratory factor analysis and an examination of between-group differences. Mathematical averages (mean scores), minimum and maximum values and standard deviations yielded a description of the data. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy (Kaiser, 1974), and the Bartlett's test of sphericity (Bartlett, 1954) were used to determine whether the data was suitable for factor analysis.

The exploratory factor analysis, using principal components analysis (PCA) at the extraction stage and the direct quartimin oblique technique at the rotation stage, was performed to reduce the items describing constraints to participating in formalised sport to a more manageable set of factors latent in the data.

Lastly, an independent t-test, Analysis of Variance (ANOVA) and a measure of effect sizes were performed to determine whether significant differences in the resulting factors were evident between various groups of respondents. Where significant differences were detected, Tukey's HSD test was used to determine where the differences occurred.

RESULTS

Characteristics of the study sample

The average age of the respondents was 21.39±4.10 years (Male: 21.54±3.91; Female: 21.29±4.27). IsiXhosa was the home language of 48%, while 22% and 19% spoke English

and Afrikaans, respectively. A further 6% spoke other languages indigenous to South Africa, such as Sesotho, Sepedi and Northern Sotho, and 5% spoke a foreign language. Males made up 44% of the respondents. Available monthly allowance for leisure was as follows: none (5%), less than R200 (43%), R201 to R400 (22%), R401 to R800 (15%) and above R800 (14%). Only 1% of the respondents did not indicate an amount.

Factor analysis

The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy (0.78) was only slightly

lower than the recommended level of 0.80 (Kaiser, 1974). The Bartlett's test of sphericity (Bartlett, 1954), reached statistical significance ($p<0.001$), detecting the correlations among the indicators. Both these measures supported the factorability of the data. Cattell's (1966) scree plot rule (retention of factors above the elbow), Horn's Parallel Analysis (PA) test (Pallant, 2013), and Kaiser's (1960) eigenvalue rule (retention of factors with eigenvalues
>1), were used to determine the appropriate number of factors.

While the scree plot did not show a clear elbow, Horn's PA test suggested 6 factors. Eight factors had an eigenvalue exceeding 1.0. Six of these factors each accounted for more than 5% of the total variance and together these 6 factors explained 60.2% of the total variance. These results met the rule of thumb that a factor solution accounting for 60% or more of the total variance is satisfactory, and a single factor accounting for 5% or more of the total variance, is meaningful (Hair *et al*., 2010).

Based on these rules and the results of Horn's test, a 6-factor solution was considered. Only items with factor loadings greater than 0.30 were regarded as contributing to that factor, thus meeting the minimum required level (Hair *et al*., 2010). Consequently, 2 items with smaller loadings were excluded from further analysis. No items appeared to cross-load onto more than 1 factor. Following a further round of rotation, the resulting factors were interpretable and therefore the 6-factor framework was deemed acceptable (Table 1). The factors' reliability coefficients (Cronbach's alpha) ranged from 0.72 to 0.81, indicating internal consistency reliability (Malhotra, 2010). Average inter-item correlation coefficients ranged from 0.31 to 0.59, and percentage variance explained per factor ranged from 9.3% to 11.0%.

As shown in Table 1, the following constraints to participation in organised sport were identified: *accessibility* (Factor 1), *time and scheduling* (Factor 2), *socialising activities* (Factor 3), *personal/psychological factors* (Factor 4), *facilities* (Factor 5) and *lack of partners* (Factor 6). *Time and scheduling* had the highest mean score and was the only factor with a mean score exceeding 3.00 on the 5-point Likert scale. *Time and scheduling* constraints seem to imply that students are too busy to participate in sport and times of organised sporting activities do not fit in with their schedules. *Accessibility* had the second highest mean score (M=2.57), indicating that transportation and affordability may prevent students from participation in organised sport. Based on mean scores, *lack of partners* (M=2.29) was ranked third and *facilities* (M=2.03) fourth. *Socialising activities* (M=1.87) and *personal/ psychological factors* (M=1.73) had mean scores below 2.0. Considering the latter 2 scores, it can be argued that time spent with family, friends and socialising on-line, and aspects, such as interest, feelings and perceptions, are of relatively little relevance in inhibiting participation in organised sport.

TABLE 1. **RESULTS OF EXPLORATORY FACTOR ANALYSIS: CONSTRAINTS**

Latent factors and questionnaire items	**Factor loading**	**Mean±SD**	**Cron-bach's alpha**	**Mean r**	**% Vari-ance**
Factor 1: Accessibility	-	2.57±1.06	0.75	0.38	9.40
Cost of transportation	0.746	2.59±1.46	-	-	-
Lack of public transportation	0.696	2.18±1.37	-	-	-
Not having my own transportation	0.747	2.77±1.67	-	-	-

No opportunities to participate where I live	0.401	2.86±1.55	-	-	-
Cannot afford to play sport	0.339	2.42±1.41	-	-	-
Factor 2: Time & Scheduling	-	3.15±0.97	0.72	0.39	9.20
Too busy with university studies	0.530	4.03±1.15	-	-	-
Do not want to interrupt daily schedule	0.509	2.33±1.27	-	-	-
Times to play sport do not fit in programme	0.799	3.13±1.43	-	-	-
Sport timetable does not fit in with mine	0.657	3.10±1.41	-	-	-
Factor 3: Socialising activities	-	1.87±0.83	0.74	0.44	10.50
Too busy with family	-0.460	2.23±1.20	-	-	-
Too busy with friends	-0.645	2.07±1.21	-	-	-
Too busy with social media	-0.666	1.71±1.10	-	-	-
Too busy socialising online	-0.634	1.47±0.90	-	-	-
Factor 4: Personal/Psychological factors	-	1.73±0.70	0.72	0.31	10.80
Playing sport is too tiring	0.544	1.84±1.09	-	-	-
Afraid of getting hurt	0.395	1.73±1.09	-	-	-
Not confident enough	0.398	1.80±1.12	-	-	-
Did not enjoy sport in the past	0.460	1.53±1.00	-	-	-
Not interested in participating in sport	0.710	1.73±1.12	-	-	-
Do not like sport activities offered	0.639	1.73±1.06	-	-	-
Factor 5: Facilities	-	2.03±0.98	0.81	0.59	7.70
Facilities are poorly kept	-0.724	1.93±1.11	-	-	-
Facilities are crowded	-0.856	2.10±1.17	-	-	-
Facilities are inadequate	-0.656	2.05±1.18	-	-	-
Factor 6: Lack of Partners	-	2.29±1.19	0.78	0.56	10.00
My friends do not like to play sport	-0.470	2.05±1.35	-	-	-
Nobody to play sport with	-0.824	2.31±1.42	-	-	-
Difficult to find others to play sport with	-0.853	2.51±1.50	-	-	-

r= Mean inter-item correlation   % Variance= % Variance explained by factor
Social media= Facebook, Twitter, Mix it, BBM   Socialising online= Chat rooms, e-mail, online forums, blogs

Results of t-tests

Independent t-tests were used to examine differences between constraints in terms of gender (Table 2). *Lack of partners* was the only factor that showed a significant difference ($p<0.05$; Cohen's d=0.39), between the genders. Females had a higher mean score for *lack of partners* compared with male respondents (2.49 and 2.03, respectively). Females also had higher mean scores than males for *accessibility* and *facilities*, but none of these differences were significant.

TABLE 2. **COMPARISON OF RESULTS BASED ON GENDER**

Factors	**Females** (56 %) Mean±SD	**Males** (44 %) Mean±SD	**Significance of differences** t-value	df	p
Accessibility	2.59±1.065	2.54±1.08	-0.33	258	0.7386
Time & scheduling	3.09±0.99	3.22±0.95	1.12	258	0.2644
Socialising activities	1.85±0.84	1.88±0.82	0.25	258	0.8062
Personal/psych. factors	1.72±0.71	1.74±0.69	0.23	258	0.8160
Facilities	2.04±1.00	2.00±0.96	-0.32	258	0.7498
Lack of partners	2.49±1.20	2.03±1.12	-3.13	258	0.0019*

*p<0.05

Results of the Analysis of Variance (ANOVA)

Anova was employed to determine whether the identified constraints differed in terms of money available for leisure activities. Table 3 shows a significant difference in the case of *accessibility*, *socialising activities* and *facilities*. *Accessibility* had the highest mean score (M=3.04) for those who had less than R100 per month to spend on leisure activities, and the lowest mean score (M=2.07) for those with more than R800. Although affordability of membership, equipment and transport costs had mean scores of below 2.60 on the 5-point scale, these factors were relevant depending on the available amount of money students had to spend on sport. It is reasonable to assume that membership, equipment and transport costs pose a greater problem to respondents with R100 and less to spend on leisure activities than to those with R800 and more available.

The mean scores for *socialising activities* were all below 2.20; those with more than R800 to spend on leisure obtained the highest score. The mean scores for *facilities* were generally higher for those respondents with less spending money than those with more money. The results of subsequent Tukey's HSD tests indicated significant pair wise differences for *accessibility* in the case of those with R100 and less relative to those with R401 to R800 ($p<0.05$; d= 0.82) and those with R801 and more ($p<0.05$; d= 0.96). A significant difference also existed between respondents with R101 to R200 and those with R800 and more ($p<0.10$; d= 0.60). Significant differences for *socialising activities* were found for those with R400 to R800 and more than R800 ($p<0.05$; d= 0.67). Differences for *facilities* occurred between the group with R101 to R200 and the group with R401 to R800 per month for leisure activities ($p<0.10$; d= 0.59).

TABLE 3. **COMPARISON OF CONSTRAINING FACTORS: MONEY AVAILABLE FOR LEISURE ACTIVITIES**

Constraints	None M±SD	R100 or less M±SD	R101-R200 M±SD	R201-R400 M±SD	R401-R800 M±SD	R80 M±
Accessibility	2.91±1.10	3.04±0.87	2.70±1.00	2.48±1.15	2.30±0.92	2.07±
Time and scheduling	2.72±0.88	3.11±1.04	3.23±0.93	3.14±0.90	3.02±1.04	3.32±
Socialising activities	1.68±0.77	1.79±0.70	1.78±0.77	2.06±0.96	1.61±0.67	2.16±
Personal/psych. factors	2.07±0.98	1.71±0.62	1.69±0.68	1.84±0.75	1.55±0.67	1.66±
Facilities	2.26±0.95	2.21±1.08	2.12±0.91	2.09±1.05	1.62±0.88	1.82±
Lack of partners	2.45±1.36	2.45±1.09	2.17±0.14	2.18±1.19	2.42±1.18	2.21±

*p<0.05 M±SD= Interval Mean±Standard Deviation

DISCUSSION

Physical, psychological and social benefits are derived from participation in sport. Organised sport offers the additional benefits of regular practice and competition, which may enhance teamwork, cooperation and loyalty. Despite these benefits, there is a worldwide decline in sport participation, also among university students, the cohort of individuals who typically might become future opinion leaders and policy makers and so have an influence on societal principles and norms. The aim of this study was to determine what prevents senior undergraduate students at the university in question, who have participated in organised sport at school, from continuing this practice as a senior student. The results showed that students mostly experience structural constraints. Interpersonal constraints seem to play a lesser role, while intrapersonal constraints are of little importance.

Intrapersonal constraints

Intrapersonal constraints include personal factors related to the psychological state of an individual, such as perceiving sport participation as too tiring, being afraid of getting hurt and lacking the interest or confidence to participate in the activity. The results of this study indicate that intrapersonal constraints did not have a significant effect on senior undergraduate students' participation in organised sport. This finding supports some previous research findings but contradicts others. For example, while intrapersonal factors had an inhibiting effect on Iranian students' participation in sport, it did not significantly affect Hungarian students (Mirsafian, 2014), and was the least constraining factor affecting sport participation by Malaysian students (Yusof & Shah, 2007), and by Greek students (Masmanidis *et al.*, 2009).

Gender did not significantly affect students' perceptions of intrapersonal constraints. In contrast, female Malaysian students experienced higher levels of intrapersonal constraints compared with their male counterparts (Yusof *et al.*, 2007).

Interpersonal constraints

Interpersonal constraints relate to social activities and the interaction between individuals. In the current study, these constraints were reflected by two factors, namely socialising activities, such as spending time with family and friends and socialising online, and finding partners with whom to share the activity. Both factors had mean scores of below 2.30 on a 5-point scale suggesting that these constraints do not significantly inhibit respondents' participation in sport. Previous researchers found similar results. For example, Drakou *et al.*

(2008) found that Greek students ranked a lack of partners only in the fourth position. While not of primary importance to Hungarian and Iranian students, Hungarian female students were particularly concerned about a lack of partners (Mirsafian (2014). The latter finding was supported by the results of the current study. *Lack of partners* received a significantly higher ($p<0.05$) mean score in the case of female students ($M=2.49$) when compared with the males ($M=2.03$).

Structural constraints

Structural constraints are external to the individual and in the current study included *time and scheduling*, *accessibility* and *facilities*. Respondents indicated that *time and scheduling* constraints were the most profound reason for not participating in organised sport. The reasons given were that they were too busy with their studies, did not have enough time for sport, and that sport schedules did not fit their programmes. No significant differences were found based in relation to gender. These findings reiterate those of Bloemhoff and Coetzee (2007:151), who cited study responsibilities and lack of time as the major constraints "in terms of sport and physical recreation participation", among third year students enrolled at a South African university. In contrast, a lack of time was only the fourth most important constraint listed by Greek students (Drakou *et al*., 2008), and was not a constraint to students at a Turkish university (Öcal, 2014), nor to students in Hong Kong (Tsai & Coleman, 2007).

Accessibility, which in the current study received the second highest ranking based on factor mean scores but did not differ based on gender, was influenced by the lack and the cost associated with transportation and the affordability of membership and equipment. Accessibility and financial constraints also played no role in the active recreation process of students in Hong Kong or in Australia (Tsai & Coleman, 2007). In contrast, accessibility was found to be the main barrier to participation in physical activities among students enrolled at universities in Greece (Alexandris & Carroll, 1997; Drakou *et al*., 2008; Masmanidis *et al*., 2009).

Facilities include quality and adequacy. In the current study, *facilities* received the third lowest mean score of all the constraints. These results are not supported by other studies. For example, facilities was the most effective factor constraining Hungarian students' sport participation (Mirsafian, 2014) and those of Malaysian students (Yusof & Shah, 2007), and the second most important factor among Greek students (Drakou, *et al*., 2008).

Hierarchical arrangement of constraints

The results of the current study show that the most profound barriers preventing undergraduate students' continued participation in organised sport from school to senior levels at university can be arranged as follows: *time and scheduling* (structural constraints), *accessibility* (structural constraints), *lack of partners* (interpersonal constraints), *facilities* (structural constraints), *socialising activities* (interpersonal constraints) and *personal/psychological factors* (intrapersonal constraints). These results suggest that the student sample did not experience constraints in a specific hierarchical order and thus supports Godbey *et al*.'s (2010) assertion that constraints can be experienced in any order. This contradicts the contention of Crawford *et al*. (1991), that constraints are experienced hierarchically with intrapersonal constraints being the most powerful and structural constraints the least powerful.

CONCLUSIONS AND RECOMMENDATIONS

The current study confirms that specific factors constrain students' participation in organised sport. These factors have an intrapersonal, interpersonal and structural nature. The most profound barrier is related to time and scheduling constraints. It is possible that the perception of a lack of time is not due to the physical number of hours available, but to the prioritising of activities. There might be merit in Tsai and Coleman's (2007) suggestion that while many cite time constraints as a justification for non-participation in sport, participants tend to make an effort to overcome time constraints. In addition to making students aware of the health benefits of sport and being physically active, and of the benefits associated with participating in organised sport, students can be trained to manage and optimally use their time. The respondents indicated that the scheduling of sport activities does not fit their schedules. Sport administration at a university could collaborate with the academic Timetabling Committee when establishing times for sport practices and matches.

The most important interpersonal constraint experienced by respondents related to the *lack of partners*. This constraint can be addressed by sport administrators through actively promoting team sport, particularly among female students, who seemed to experience more difficulties in this regard than male students did. Not only does team sport foster a sense of belonging, the set times for sport practices and matches make members more accountable to the team, and hence finding a co-participant makes it less constraining.

LIMITATIONS AND IMPLICATIONS FOR FURTHER RESEARCH

This study is not without its limitations and, therefore, also reveals opportunities for future research. Firstly, geographically, the research was restricted to students enrolled at certain campuses of the university. Investigating the constraints to students' participation in organised sport across all the campuses may provide opportunities for a comparative study, given the different physical locations of the campuses excluded from the current study. Secondly, the research focused on constraints to sport participation in an organised, formalised context. Further research on informal sport participation and the physical activity preferences of students could enhance the understanding of constraints. Another comparative analysis of constraints to participation in sport on a formalised level could be undertaken using students who participated at school, but did not continue at university level, students who occasionally participate in organised sport and those who participate on a regular basis.

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EFFECT OF DIFFERENT INSTRUCTIONAL MEDIA ON ACQUISITION OF MARTIAL ARTS SKILLS BY ELEMENTARY SCHOOL STUDENTS

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ABSTRACT

This study investigated the effects of different instructional modes on teaching one of the popular martial arts, Baduanjin. The Grade-4 learners (N=81) that were recruited were assigned to one of three groups: picture-based instruction, video-based instruction and live-modelling instruction. All the students received four instruction sessions within two weeks. The measurements were a retention performance test conducted immediately after the students completed all the instruction sessions and another retention performance test conducted four weeks later. Through the analysis of one-way ANOVAs, significant differences were identified in the scores of the three groups. Students who received the picture-based instruction exhibited lower performance accuracy than those who received video-based and live-modelling instruction in both their retention and delayed retention tests. No significant difference was found between the video and the live-modelling groups. The implications of these results for the design of computer-assisted motor skills learning are discussed.

Key words: Elementary education; Physical education; Multimedia instruction; Martial arts.

INTRODUCTION

The integration of Information and Communication Technology (ICT) into physical education (PE) has been receiving increased attention over the last decade (Thomas & Stratton, 2006). The results from numerous studies have indicated the positive impacts of ICT on PE (Antoniou *et al.*, 2003; Golshani *et al.*, 2004), such as facilitating the learning of basketball rule violations (Antoniou *et al*., 2003), improving sailing and sport training knowledge (Leblanc *et al.*, 2001), and enhancing health-related knowledge (Siskos *et al*., 2005). In addition, ICT can be used to support the comparison and analysis of dance and human movement (Golshani *et al*., 2004), and basketball coaching skills (Papastergiou & Gerodimos, 2013).

Given the popularity of the Internet, the World Wide Web now plays an essential role in education. Researchers of educational technology have identified many advantages of Web-based instruction, including providing a sound forum for learning to occur anytime and anywhere (Liaw, 2008), allowing individual and collective publishing and sharing of images, audio and video (Bennett *et al.*, 2012), and supporting self-directed learning (Wang, 2011). In order to embrace the merits of Web-based instruction in improving PE, several researchers (Leijen *et al.*, 2009; Huang *et al.*, 2011), have sought to integrate the Internet into the enhancement of motor learning. For instance, the study of Huang *et al.* (2011) developed a Web-based learning platform for teaching motor skills, regulations and first-aid instruction to increase the effectiveness of PE courses and to promote motivation among learners.

To support the reflection process of dance students and learning from multiple perspectives, Leijen *et al.* (2009) utilised online video streaming as a way to help students describe their choreographic work and perform peer assessment of the recorded practice online. The results from both studies demonstrated the effectiveness of the implementations. Based on the above description, computer-assisted motor learning, especially that incorporates the approach of Web-based instruction, has become a growing trend in PE. This is happening not only because this instructional method provides the characteristics of convenience, flexibility and interaction, but also because it offers abundant opportunities for students to acquire the targeted knowledge or skills (Kooiman & Sheehan, 2014).

Demonstrating a motor skill in front of students is a fundamental and effective teaching approach (Lee *et al.*, 1991; Wulf *et al.*, 2005). According to some researchers (Bandura, 1986; Granados & Wulf, 2007), most people can acquire motor skills by observing a model. This acquisition process consists of several essential elements necessary for an observer to remember the model‟s behaviour to generate proper information to develop cognitive representation for regulating motion (Carroll & Bandura, 1990). In addition, the results of Carroll and Bandura (1990) have also suggested that the more one is exposed to the modelled motions, the more accurate one‟s cognitive representation and behavioural reproduction will be.

In implementing Web-based instruction for motor learning, many researchers and educators are seeking the solution of replacing real live modelling with video demonstration. Examples of adopting this approach include using an online video-based learning environment to facilitate acquisition of ballet by college students (Leijen *et al.*, 2009), and developing computer-based instructional video lessons to help college students acquire the fundamental skills associated with golf swings (Huang, 2000). Similarly, basketball (Papastergiou & Gerodimos, 2013) and gymnastics skills (Lim & Koh, 2006), were also enhanced by using Web-based multimedia. Although the findings from both studies identified positive impacts on the learning of participants, it is still uncertain whether the same effects will appear in connection with implementing online video-based PE in an elementary school context.

Researchers of multimedia instruction (Mayer *et al.*, 2005) have proposed that static media (like pictures), offer the opportunity for better management of intrinsic processing; in which one cannot only control the pace and sequence of presentations, but also engage in deeper processing by mentally making inferences or connections with the pictures. Thus, in addition to online video-based instruction, this study also attempted to examine the effects of online picture-based instruction on students‟ acquisition of motor skills. Although the video-based and picture-based modes of instruction can be cost-effective and time-efficient, utilising these materials as alternatives to live instruction, especially for the motor acquisition of elementary school students, is unknown currently.

PURPOSE OF RESEARCH

The purpose of the present study was to determine whether different modes of instruction affect the learning of the martial art Baduanjin, as measured by a retention test of performance skills conducted immediately after the instruction sessions and again after 4 weeks. This study was intended to answer the research question: What were the effects of picture-based, video-based, and live-modelling instruction on the students‟ acquisition of the martial art? Since previous studies have pointed out that live modelling is an effective and efficient instructional approach for motor learning, this study was designed to assess whether video- or picture-based instruction can be as effective as live-modelling instruction.

METHODOLOGY

Ethical approval

After submitting the manuscript proposing the research to the Human Subject Committee of the National Taiwan Sport University, ethical clearance was approved. The results reported in this article were undertaken in compliance with the current laws of the country in which the experiments were performed. The authors accept full responsibility for the statements made.

Participants

Through convenience sampling, 3 classes in an elementary school of Northern Taiwan were recruited to participate in the present study. There were 81 fourth graders recruited in total. Of these students, 4 were excluded from analysis because they failed to take either the retention or the delayed retention test due to being injured or physically ill. The remaining 77 subjects were in the 3 classes and each class was assigned randomly to 1 of the 3 groups. These groups entailed the „picture group‟ utilising pictures and text as the main instructional sources (11 males and 13 females); the „video group‟ using video and text (12 males and 12 females); and the „live demonstration‟ group, in which the students learned the motor skills face to face with a martial arts expert (16 males and 13 females). The participants were informed and everyone returned consent forms signed by their parents. The self-reported data showed that none of the students had ever learned this particular martial art before. In addition, the physical fitness of the participants was examined and no statistically significant differences were found in the scores for their body mass index ($F_{(2, 74)}= 1.41$; $p>0.05$), flexibility ($F_{(2, 74)}= 2.10$; $p>0.05$) or strength ($F_{(2, 74)}= 0.01$; $p>0.05$), suggesting that the physical ability of each group could be considered equal.

Experimental instrument

A Baduanjin learning system was developed by the researchers to facilitate the teaching of this popular Chinese martial art. Baduanjin consists of 8 sections: 1) Pressing up to the heavens with two hands; 2) Drawing the bow and letting the arrow fly; 3) Separating heaven and earth; 4) Wise owl gazing backward; 5) Big bear turning from side to side; 6) Punching with an angry gaze; 7) Touching the toes then bending backward; and 8) Shaking the body. Each section contains sub-motions numbered 9 to 18, which are listed in Table 1. Indicators of the levels of difficulty and duration of each section, suggested by the Baduanjin expert, are also provided. As shown, sections 2 and 3 have a high difficult level, while sections 1 and 8 have a low level of difficulty. The duration of the difficult sections tends to be longer than that of the less complex sections.

TABLE 1. **DESCRIPTION OF BADUANJIN SECTIONS**

Name	**Section 1**	**Section 2**	**Section 3**	**Section 4**	**Section 5**	**Section 6**	**Section 7**	**Section 8**
Num. of sub motions	12	18	15	12	15	18	15	9
Duration/ seconds	24	40	45	26	41	29	31	5
Level of difficulty	Low	High	High	Low	Medium	Medium	Medium	Low

The Baduanjin learning system used here was designed by, first, filming the demonstration of an expert who has been practising and coaching Baduanjin for more than 10 years. The video content was separated into 8 pieces corresponding to the 8 sections of Baduanjin. The narration of the expert was transcribed into text and the researchers examined the text information for the 3 groups to make sure that they were identical. Students in the video group could watch the video clip and read the text guidance. They could also pause and replay the clip if needed (Figure 1).

FIGURE 1. **INTERFACE OF LEARNING SYSTEM FOR VIDEO GROUP**

The illustrations used in the picture group were extracted from the key images of the video clip. The students could look at the images and read the text guidance located below the pictures (Figure 2). The text guidance was presented in Mandarin Chinese. The images could be enlarged by clicking on them. No specific learning sequence was imposed while using either the picture- or video-based instruction. That is, the participants were allowed to select which motion to learn first. Both systems conveyed the same information, but it was presented differently.

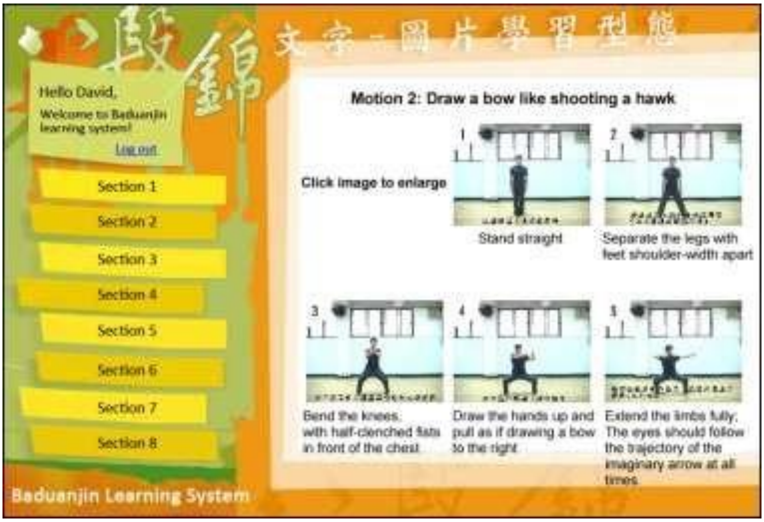

FIGURE 2. **INTERFACE OF LEARNING SYSTEM FOR PICTURE GROUP**

Procedure

The instruction sessions took place 4 times within 2 weeks (on every Monday and Thursday). Each session lasted 40 minutes. At the beginning of the first instruction session, the researcher offered a brief introduction of the research and its purposes to all the groups. All participants were aware that they would undergo an evaluation of their learning after completing the 4 instruction sessions.

The experiments for the „picture" and „video" groups were conducted in a computer lab. Each student worked individually at a computer and was asked to sit separately (with 1 empty seat on either side) to ensure sufficient space to practise. To start the instruction session, the students were given a code and password to log into the system, which allowed the researchers to track history of usage of the participants. They were told to remain silent during the activity and to raise their hands if they had any questions related to using the system. During each instruction session, the participants went through each section of the instructional media and practised Baduanjin at their own pace.

The instruction sessions for the live-modelling group took place in the gym. The students learned Baduanjin from an experienced instructor whose teaching guidance was identical to the content being viewed by the picture and video groups. The teacher spent 10 minutes on demonstration and the remaining 30 minutes on observing the practise of the students. During the practise, no discussion among the students was allowed and the instructor gave no feedback on their performance. This was to maintain the balance of the research design since immediate feedback is less likely to be given when self-learning motor skills through an online learning system.

Evaluation measurement

An immediate and a 4-week delayed retention test were conducted to evaluate the motor performance of the students after the instruction sessions had concluded. Each group was divided into 3 subgroups. When 1 subgroup was receiving a test, the other 2 were in a separate room watching a movie that was unrelated to the targeted content of the present study. To prevent the students of the subgroup from being able to imitate one another during the test, the researcher had each participant pick up a card printed with a sequence of codes (from 1 to 8, representing the 8 sections of Baduanjin), where each sequence had a different initial number. Thus, every student worked through the 8 sections of Baduanjin in a different sequence. In addition, 2 video cameras were set up to record the performance of the students from the front and front-right views. The researcher separated the video clips of the performance and named them according to the ID numbers of the students.

Two qualified PE teachers were invited to grade the student clips using an evaluation form designed by the Baduanjin expert. Both teachers had been learning Baduanjin for 2 years. Each section of Baduanjin was measured at 3 stages: preparation; pre-motion; and post-motion. During these stages, every student was graded in terms of their eyes (whether he or she was looking at the designated spot), body, limbs, footsteps and conformance with rules (whether the motion was performed at the appropriate pace). Due to the different complexities of the 8 sections of Baduanjin, each section was evaluated based on 8 to 13 criteria using a 5-point Likert scale (where “1” = inaccurate and unskilful, and “5” = accurate and skilful). The full scores for each section, ranging from 40 to 65, were converted into percentages. A person‟s overall performance was captured by the average of the scores on the 8 sections. The tester reliability of the 2 graders reached Cronbach‟s α-value of 0.88 (suggested adequate value >0.70), indicating good internal consistency (Allen & Yen, 2002). A 4-week delayed retention test was conducted following the same process as that of the first retention test.

Data analysis

A series of one-way analysis of variance (ANOVA) was employed in this study to examine differences in the retention and delayed retention scores of the students. Following ANOVA, Scheffe analyses were performed to identify differences among groups. All statistical analyses were conducted and significance awarded at the level of $p<0.05$.

RESULTS

ANOVA analyses were applied to compare the participants‟ scores on the immediate and the delayed retention tests. Once a significant F-value was identified in the analysis, post hoc tests were used to examine the significance of all possible pair-wise comparisons among groups. Table 2 shows the performance of the students on the retention and delayed retention tests. As shown, the students in the „live-modelling‟ group had the highest accuracy rate in the retention (68.83±14.96%) and delayed retention test (63.27±10.42%), whereas those in the „picture-based‟ group had the lowest accuracy rate in the retention (50.48±17.28%) and delayed retention test (43.83±14.30%).

Meanwhile, statistically significant differences were identified in the retention ($F_{(2, 74)}= 9.62$; $p<0.01$) and delayed retention scores ($F_{(2, 74)}= 15.71$; $p<0.001$), of the participants. Furthermore, a series of post hoc tests (Scheffe tests) were performed to compare further the differences among the groups. The results indicate that students in both the „video‟ and „live-modelling‟ groups scored significantly higher than those in the „picture group‟ did in both the retention and delayed retention tests.

TABLE 2. **ANALYSIS OF PERFORMANCE OF STUDENTS ON RETENTION AND DELAYED RETENTION TESTS**

Group	**Retention** Mean±SD	**Delayed retention** Mean±SD
(1) Picture group (n=24)	50.48±17.28	43.83±14.30
(2) Video group (n=24)	62.32±13.34	54.90±13.11
(3) Live modelling group (n=29)	68.83±14.96	63.27±10.42
F (ANOVA)	9.62***	15.71***
Post hoc tests	(2)>(1), (3)>(1)	(2)>(1), (3)>(1)

*** p <0.001

DISCUSSION

While the integration of technology into motor learning has seen an increasing trend in the last decade (Hergüner, 2011; Kizilet, 2011), there is still a lack of studies on implementing technology, particularly the Internet, in PE in the elementary school context. The present study was conducted to examine the effects of the „picture-based", „video-based" and „live-modelling" modes of instruction on the acquisition of Baduanjin skills by fourth graders. The results of the immediate and the delayed retention tests indicate that the „video" and „live-modelling" modes of instruction were more effective than the „picture-based" instruction. That is, learners in the „picture-based" group tended to make a greater number of errors than those who received the „video-based" and „live-modelling" instruction. This finding is indicative of the results of Reo and Mercer (2004), where the effect of using live modelling, videotape, and hand-outs (containing pictures and text), on learning an exercise programme was compared. They found that students who received „live-modelling" or „video" instruction outperformed those who learned from „reading the hand-out materials" on both the immediate and delayed retention tests.

According to Shea *et al.* (2000), novice learners tend to benefit greatly from direct observation of demonstrations together with physical practise as they can extract relevant information regarding proper coordination patterns and evaluate strategies. This may be a factor contributing to the positive impacts of both „video-based" and „live-modelling" instruction in this study. „Picture-based" instruction, despite offering the key pictures of each movement, does not seem to provide sufficient information for learners to perceive the coordination and in-between actions of the complex Baduanjin movements. Based on findings of the present study and previous research, it is preferable to utilise „video" content rather than „static pictures" when designing digital learning materials for motor learning.

Many studies have indicated that immediate feedback plays a critical role in the learning of motor skills (Newell, 1991; Winstein *et al.*, 1996). However, immediate feedback was controlled in the present study because it remains challenging to provide it through either online „picture-based" or „video-based" instruction. Thus, to maintain the balance of the experimental design, immediate feedback was not provided to the live-modelling group.

Although the results show that online „video-based" instruction can be as effective as „live-modelling" instruction, future research should develop ways to improve online video-based instruction. Some suggestions include, to begin with integrating cooperative learning into teaching (Granados & Wulf, 2007); that is, having students practise „video-based" motor learning activities online in dyads to allow them to conduct observations and do peer assessments on each other.

Studies have found that watching novice demonstrations can also promote the acquisition of the motor skills of students (Lee & White, 1990; Rohbanfard & Proteau, 2011). This is not only because an unskilled model can provide valuable information for improving the task, but also because the observer can be engaged in the problem-solving process involved in motor acquisition (Adams, 1986). Thus, the second approach to improve online „video-based" instruction is to provide a pool of video clips of demonstrations not only by an expert model, but also by a novice model for learners to observe. An interesting topic drawn from this discussion is whether there is any difference in the effectiveness of first presenting a novice demonstration or an expert demonstration. Another suggestion for future studies is to examine the impact of the ages of participants on the learning outcomes. It is likely that Grade 4 learners might learn differently from older or younger grades. In addition, the sample size of this study was small and the participants were from one school thus, the results could not be generalised. Future studies should avoid these issues.

CONCLUSION

To summarise, this study found that „video-based" and „live-modelling" instruction are more effective than „picture-based" instruction in this group of children. Particularly, when there is no live model to imitate, video and text can be an effective learning tool to facilitate motor acquisition. The prevalence of child obesity is increasing rapidly worldwide (Han *et al.*, 2010). Offering alternative approaches to motivate participation in physical activities anytime and anywhere has thus become of great importance. Online „video-based" instruction can be an ideal option. Further research is needed to examine how different modes of instruction can promote the motivation of the learner to participate in activities or to perform motor skills that are more complex. In addition, since the age of the participants might play an essential role in the results, further research should also address the effects of these instructional media on participants of different ages.

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SPORT PSYCHOLOGICAL SKILLS PROFILE OF TRACK AND FIELD ATHLETES AND COMPARISONS BETWEEN SUCCESSFUL AND LESS SUCCESSFUL TRACK ATHLETES

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ABSTRACT

The aim of this study was to compile a sport psychological skills profile of track and field athletes and to compare the psychological skill levels of successful and less successful track athletes during the 2011 University Sport South Africa Athletics Championships. The participants included 143 athletes (age= 21.6±2.32 years). Their perceived importance and need for psychological skills training, as well as their perceived ability to be mentally prepared for training sessions and competitions were investigated. Practical significant differences were observed between the top (n=21) and bottom (n=21) sprinters for Peak Performance Profile (PPP) total and stress control, Psychological Skills Inventory (PSI) total and achievement motivation, as well as between the top (n=21) and average (n=20) sprinters for PPP total, concentration, stress control, PSI total, achievement motivation, maintaining self-confidence and concentration. The successful (n=21) middle- and long-distance athletes recorded significantly higher achievement motivation values than their less successful (n=21) counterparts. Collectively, these results confirm a relationship between psychological skills and track and field success. The effect of psychological skills training programmes on psychological skills development and performance enhancement requires further empirical studies.

Key words: Track and field athletes; IAAF scores; Performance; Sprinters; Middle- and long-distance athletes.

INTRODUCTION

Pierre de Coubertin proposed the Olympic motto, *Citius*, *Altius*, *Fortius*, a Latin phrase meaning faster, higher, stronger (Van der Merwe, 2005). Although this motto is not limited to the sport of track and field (commonly referred to as athletics), these objectives are especially relevant to this sport. Most athletics events are individual contests with athletes challenging each other to decide a single victor. Depending on the particular event, many different factors, such as talent, training, trainability, physical factors, body composition, nutritional status, technique, tactical awareness, motivation and other psychological characteristics have been shown to contribute to sport success (Maughan, 2009).

Sport challenges athletes both physically and psychologically, due to the diversity, unpredictability and intensity of training and competition (Kumar & Shirotriya, 2010). Noakes (2003) believes that the preparation of the mind is as important to perform as physical preparation. Elite performers require a "psychological edge that enables them to generally cope better than their opponents with the many demands (e.g. competition, training, life style), that sport places on a performer" (Jones *et al*., 2002:209). These researchers noted that successful athletes tend to be more determined, focused, confident and in control despite the pressures and demands that top-level sport places on them. Vernacchia *et al*. (2000) observed that the use of imagery, perseverance and confidence were related strongly to Olympic track and field success. Gould *et al*. (2002a) highlighted the ability of Olympic athletes to cope, control their anxiety, focus and block out any distractions, and to set and achieve their goals. In addition, they possessed high levels of confidence, sport intelligence, hope, optimism and adaptive perfectionism, and demonstrated competitiveness and a strong work ethic. Olympic medallists exhibited greater emotional control and experienced less negative thinking than the non-medallists experience (Taylor *et al*., 2008). Iranian medal winners (during the Asian Games), were shown to react more positively to stress than the non-medal winners (Salmela *et al*., 2009), whilst elite Greek athletes were better than their non-elite counterparts with regard to emotional control, goal setting, imagery, activation, positive thinking and relaxation (Katsikas *et al*., 2009).

MacNamara *et al*. (2010) identified psychological factors as key determinants that enable talented athletes to turn their potential into optimal performance. Hard work, motivation and the ability to perform under pressure are essential performance determinants (Butt *et al*., 2010). Kruger and Pienaar (2012) found that talented junior sprinters were more effective in setting goals than less talented sprinters. Hollings *et al*. (2014) observed that having a significant commitment to a clearly defined and realistic goal was the primary reason why some elite juniors went on to become successful senior track and field athletes and others did not.

Coaches play a critical role in enhancing psychological skills and creating a positive but tough practice environment. Olympic coaches believe that their athletes need to have plans to deal with distractions and that high confidence levels are required for optimal performance (Gould *et al*., 2002b). However, Leslie-Toogood and Martin (2003) noted that track coaches were unable to assess the mental strengths and weaknesses of their athletes accurately, despite being confident in their ability to do so. Furthermore, Weinberg and Gould (2011) observed that psychological skills training (PST) is often neglected by coaches due to a perceived lack of time and a limited understanding of how to teach and practise psychological skills.

Gould *et al.* (2009:53) defined psychological preparation as "cognitive, emotional, and behavioural strategies athletes use to arrive at an ideal performance state or condition that is related to optimal psychological states and peak performance either for competition or practice". Arousal regulation, imagery/mental preparation, self-confidence, motivation, commitment, goal setting and attention/concentration skills should be developed by athletes in order for them to perform successfully (Weinberg & Gould, 2011). PST, in combination with physical training, has been shown to improve performance more than physical training alone (Kumar & Shirotriya, 2010). The work of Wann and Church (1998) underlined the importance of PST programmes and mental preparation in the sport of track and field. A PST programme, consisting of relaxation skills, self-talk, goal setting, imagery and concentration skills, resulted in significantly improved performances among middle-distance athletes (Pieterse & Potgieter, 2006).

Interventions aimed at developing sport psychological skills are mapped typically within Cognitive-Behaviour Therapy (CBT). CBT is the most widely used model in sport psychology and has been used successfully in various settings. It is an umbrella term for the two approaches originally based on cognitive therapy and behavioural therapy and describes interventions that aim to decrease psychological distress and maladaptive behaviours by modifying cognitive processes (Hill, 2001). This model emphasises the interaction between current situations, cognitions (what we think), emotions (what we feel) and behaviours (what we do). CBT primarily focuses on methods that strengthen positive and weaken negative behaviour (Behncke, 2004). Over time, it conditions the individual to think in specific ways to create the desired psychological states. The goal of CBT is to change the way the athlete approaches a given task and to lay the foundation for implementing specific performance-enhancement techniques.

AIM OF STUDY

The aim of this study was to compile a sport psychological skills profile of student track and field athletes and to compare the sport psychological skill levels of successful and less successful track athletes based on their performance during a competition.

METHODOLOGY

Research design

A cross-sectional design was used to survey the sport psychological skill levels and athletic performance of participants at the 2011 University Sport South Africa (USSA) Athletics Championships, A-section.

Ethical issues

The Research Ethics Committee approved this study: Human Research (Non-health) of Stellenbosch University (Ref. 485/2010).

Participants

The study used an availability sample of 143 student athletes (75 male and 68 female) with a mean age of 21.6±2.32 years from 5 South African universities. Participants were included if they completed both measuring instruments and competed in at least 1 event during the Championships. Some athletes competed in more than 1 event, but only their best performance was used for further analysis. The group consisted of 62 sprinters (100m, 200m, 400m, 100mH/110mH or 400mH), 42 middle- and long-distance athletes (800m, 1500m, 3000m SC, 10km or 21km), 17 jumpers (high-jump, long-jump or triple-jump), 16 throwers (javelin, discus or shot put), and 6 multi-event athletes (male decathletes and female heptathletes).

Procedures

The USSA Athletic Championships organising committee granted permission for the study to be conducted. Team managers from all the participating teams were given an overview of the study and were asked to allow and encourage their athletes to take part. Thereafter, the study was also explained to all the willing participants. Participation in the study was voluntary and participants were free to withdraw from the study at any time and without prejudice. Anonymity and confidentiality of information were guaranteed in order to reduce the possibility of socially desirable answers. All participants signed informed consent forms before completing the PSI and PPP in a classroom setting, before taking part in any events.

Measuring instruments

Psychological Skills Inventory (PSI)

Wheaton (1998) developed the PSI after an extensive review of sport psychology literature. A provisional 82-item inventory was administered to 304 sport science students. Test-retest reliability (over a period of 1 week) yielded correlations ranging from 0.79 to 0.97. The 10 items that correlated best from each mental skill were included in a 60-item inventory. It measures the following 6 sport psychological subscales (with 10 items contributing to each):

achievement motivation; goal directedness; activation control; maintaining self-confidence; concentration; and imagery. The items are scored on a 5-point Likert-type scale anchored by descriptors ranging from “Never” [0] to “Always” [4]. Reversed scoring applies to 19 of the 60 items. Results are expressed as percentage scores, with higher values reflecting better sport psychological skill levels. Preliminary results showed that this inventory could differentiate between successful and less successful athletes. However, Wheaton, recommended that the inventory should be subjected to further testing. The study of Eloff *et al*. (2011), on field hockey players in South Africa, yielded acceptable α"s ranging between 0.77 and 0.85 for the 6 subscales, and 0.81 for the PSI total score.

Peak Performance Profile (PPP)

The above-mentioned PSI was administered over a period of more than 5 years to 768 elite sportspersons, who were part of the government-sponsored *Sport Information and Science Agency* (SISA) high-performance programme. A Confirmatory Factor Analysis (CFA) was performed on the data, which produced disappointing results (Potgieter & Kidd, 2011). These included a Root Mean Square Error of Approximation (RMSEA) of 0.13 (acceptable value: $p<0.05$), a Goodness-of-Fit Index (GFI) of 0.8 (acceptable value: >0.95), and an Adjusted Goodness-of-Fit index (AGFI) of 0.79 (acceptable value: >0.95). The data were split into a calibration and a validation sample. After an Exploratory Factor Analysis (EFA), 4 independent factors (concentration, confidence, stress control and visualisation), that included 22 items emerged with loadings of >0.5. These factors explained 61% of the variance. Consequently, it was decided to present these items as a profile of mental attributes (namely the Peak Performance Profile), instead of an inventory of psychological skills. As visualisation did not follow this line of reasoning, it was eliminated. The CFA of the 13 remaining items, yielded satisfactory goodness-of-fit scores (RMSEA= 0.041; GFI= 0.99; AGFI= 0.98). The variance extracted and Chronbach α for concentration (0.59 and 0.85) and stress control (0.56 and 0.82), were satisfactory, whilst it was just under the normal threshold for confidence (0.50 and 0.70).

Two new items were added to the confidence subscale for future analysis. The authors envisaged additional development of the confidence subscale as part of the next phase in the development of the instruments. At present, the instrument consists of 15 items, scored on a 5-point Likert-type scale anchored by descriptors ranging from “Never” [0] to “Always” [4]. Reversed scoring applies to 8 of the 15 items. Results are expressed as percentage scores, with higher values reflecting better mental attributes. Table 1 reports the Chronbach α coefficients for the PSI and PPP calculated for the current data set and shows satisfactory internal consistency ranging from 0.71 to 0.86.

TABLE 1. **INTERNAL CONSISTENCY COEFFICIENTS FOR PSI AND PPP**

Psychological skills subscale	**Chronbach α**
Psychological Skills Inventory (PSI) Total	0.85
* Achievement motivation	0.72
* Goal directedness	0.82
* Activation control	0.83
* Maintaining self-confidence	0.86
* Concentration	0.77

* Imagery	0.84
Peak Performance Profile (PPP) Total	0.86
* Confidence	0.71
* Stress control	0.83
* Concentration	0.72

Dependent variable

The dependent variable was the performance of the athletes as calculated from the 2011 IAAF scoring tables. These tables express individual athletic performances as points, allowing a direct comparison of athletes across different events, genders and ages. The IAAF scores were calculated for each event in which the athletes competed, with the best performance used for further analysis in cases where the athletes participated in more than 1 event.

Statistical analysis

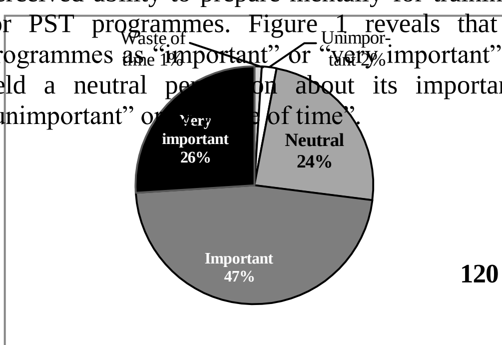
The Statistical Data Processing package was used to analyse the data (StatSoft, Inc., 2010). Descriptive statistics (mean and SD) were calculated. A one-way analysis of variance (ANOVA) was used to determine the differences between the bottom 21, average 20 and top 21 sprinters regarding their sport psychological skill levels. The t-test was used to compare the bottom 21 and top 21 middle- and long-distance athletes. The jumpers, throwers and multi-event athletes were not compared due to the small sample size. Statistical significance was set at $p \leq 0.05$. Effect sizes (ES) were calculated for each of these comparisons according to the formula described by Thomas *et al.* (2005), ES= $(M_1 - M_2)/s_p$ where M_1= mean value of the first group, M_2= mean value of the second group and s_p= pooled standard deviation.

$$s_p = \sqrt{\frac{s_1^2(n_1-1)+s_2^2(n_2-1)}{n_1+n_2-2}}$$

Here, S_1^2= the variance of the participants of the first group; S_2^2= the variance of the participants of the second group; n_1= number of participants in the first group; n_2= number of participants in the second group. Effect sizes of around 0.8 indicate large practical significance, around 0.5 indicate moderate practical significance, and around 0.2 indicate small practical significant differences.

RESULTS

Figure 1 to Figure 5 depict the perceived importance of PST programmes of the athletes, their previous consultations to sport psychologists and/or exposure to PST programmes, their perceived ability to prepare mentally for training sessions and competitions, and their need for PST programmes. Figure 1 reveals that 73% of the total group perceived PST programmes as "important" or "very important". Almost a quarter (24%) of the participants held a neutral perception about its importance, whereas only 3% deemed it to be "unimportant" or a "waste of time".



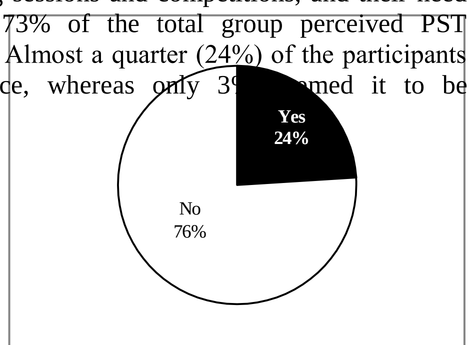


FIGURE 1. **PERCEIVED IMPORTANCE OF PST PROGRAMMES**

FIGURE 2. **PREVIOUS CONSULTATION WITH SPORT PSYCHOLOGIST AND/OR EXPOSURE TO PST PROGRAMMES**

Despite the perceived importance of PST programmes as illustrated by Figure 1, only 24% of the participants had previously consulted a sport psychologist and/or had any exposure to PST programmes (Figure 2).

Figure 3 illustrates similar results with regard to the perceived ability to prepare mentally for training sessions and competitions of the athletes. These figures also showed that 40% of the participants could potentially benefit from PST as they rated their ability to be mentally prepared as "average" or "below average".

Despite the potential room for improvement implied by the results depicted in Figures 3, 44% of the participants were "uncertain" about their need for PST programmes, with a further 12% expressing "no need" for such programmes (Figure 4). Encouragingly, the remaining 44% expressed a "need" or "great need" for PST.

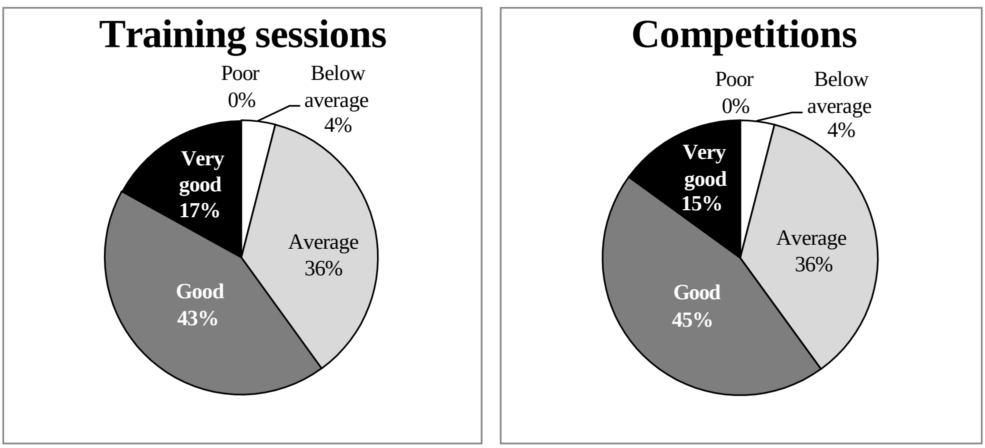


FIGURE 3. **PERCEIVED ABILITY TO PREPARE MENTALLY FOR TRAINING SESSIONS AND COMPETITIONS**

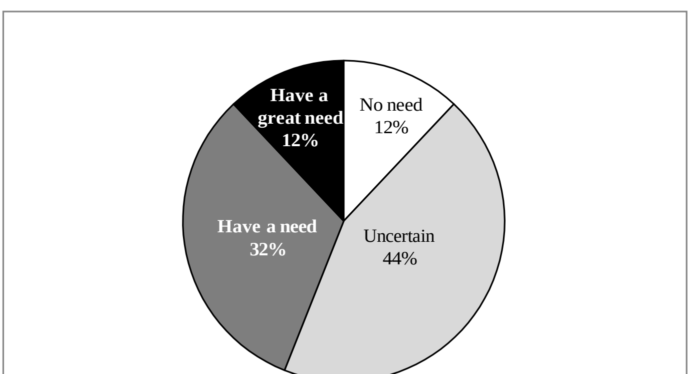


FIGURE 4. **EXPRESSED NEED FOR PST PROGRAMMES**

Table 2 contains the descriptive statistics (Mean±SD) of the total sample (N=143) and each of the 5 subgroups regarding their psychological skills and athletic performance. The lowest mean scores of the total sample were recorded for „confidence" (56.4±15.78%), whereas „achievement motivation" yielded the highest mean scores (75.7±10.45%). These results indicate substantial room for improvement with regard to psychological skills of student track and field athletes. The sprinters were the largest subgroup (n=62), and on average achieved the best IAAF scores (918.6±119.70 points). The multi-event participants were the smallest group (n=6) and obtained the lowest IAAF scores (681.3±248.44 points) during the championships.

Table 3 provides the psychological skill scores (measured with the PSI and PPP) for the 3 groups of sprinters (categorised according to their IAAF scores): Bottom 21 (scores ranged from 530 to 896); Average 20 (903 to 972); and Top 21 (980 to 1099). Figure 5 and Figure 6 depict the comparison of the PPP and PSI subscales scores of the 3 groups of sprinters. From this table and figures, it is clear that the Top 21 sprinters had a significantly higher PPP total, stress control, PSI total, achievement motivation and concentration scores than the Average 20 and Bottom 21 sprinters. The Top 21 sprinters also outperformed the Average 20 sprinters in maintaining self-confidence. Collectively, these results show that more and less successful sprinters can be distinguished as a function of their psychological skill levels.

Table 4, Figure 7 and Figure 8 show the PSI and PPP subscale comparisons between the Bottom 21 (IAAF scores range: 131 to 891) and the Top 21 (scores: 896 to 1066) middle- and long-distance athletes. It shows that the more successful athletes obtained slightly better scores than the less successful athletes for each of the psychological skill subscales except for concentration (as measured with the PPP). The only significant difference, however, was observed for „achievement motivation" in which the Top 21 athletes obtained better values than the Bottom 21 athletes (Top 21: 78.9±11.25%; Bottom 21: 73.2±8.45%).

TABLE 2. **PPP AND PSI PROFILES AND IAAF SCORES OF TOTAL SAMPLE AND FIVE SUBGROUPS**

Parameters	**TOTAL SAMPLE** (N=143) M±SD %	**SPRINTERS** (n=62) M±SD %	**MIDDLE/LONG DISTANCE** (n=42) M±SD %	**JUMPERS** (n=17) M±SD %	**THRO** (n=1 M±S
PPP Total	60.0±13.84	58.3±14.00	58.6±13.60	66.3±11.90	64.8±
* Concentration	56.7±17.37	55.3±16.19	53.8±18.77	66.2±14.63	60.0±
* Stress control	66.9±16.24	64.0±16.22	68.3±16.40	72.4±16.40	69.7±
* Confidence	56.4±15.78	55.6±16.35	53.7±14.69	60.3±14.84	64.7±

PSI Total	63.5±10.40	62.5±10.72	64.1±9.60	64.2±12.07	64.9±
* Achievement motivation	75.6±10.45	74.5±10.40	76.1±10.24	76.6±12.90	77.5±
* Goal Directedness	70.1±15.09	69.3±14.98	73.6±13.00	61.6±19.34	71.4±
* Activation Control	56.9±15.11	55.3±15.52	55.7±14.62	61.0±14.42	62.7±
* Maintain self-confidence	59.4±12.07	57.3±12.75	59.0±10.58	63.7±14.06	63.9±
* Concentration	59.7±13.74	58.4±12.57	58.3±14.11	66.2±13.26	62.2±
* Imagery	59.3±16.78	60.1±15.61	61.7±13.72	55.9±19.28	51.7±
IAAF score	877.1±157.22	918.6±119.70	839.0±200.16	894.7±83.94	865.6±

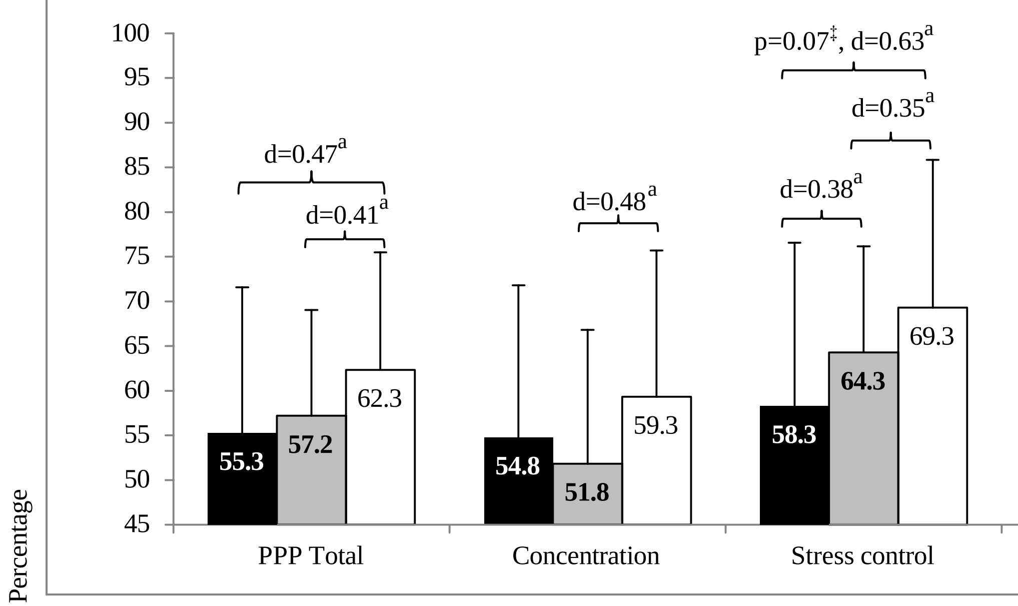
M= Mean SD= Standard Deviation

Percentage

TABLE 5. **COMPARISON OF PPP, PSI AND IAAF SCORES OF THREE GROUPS OF SPRINTERS**

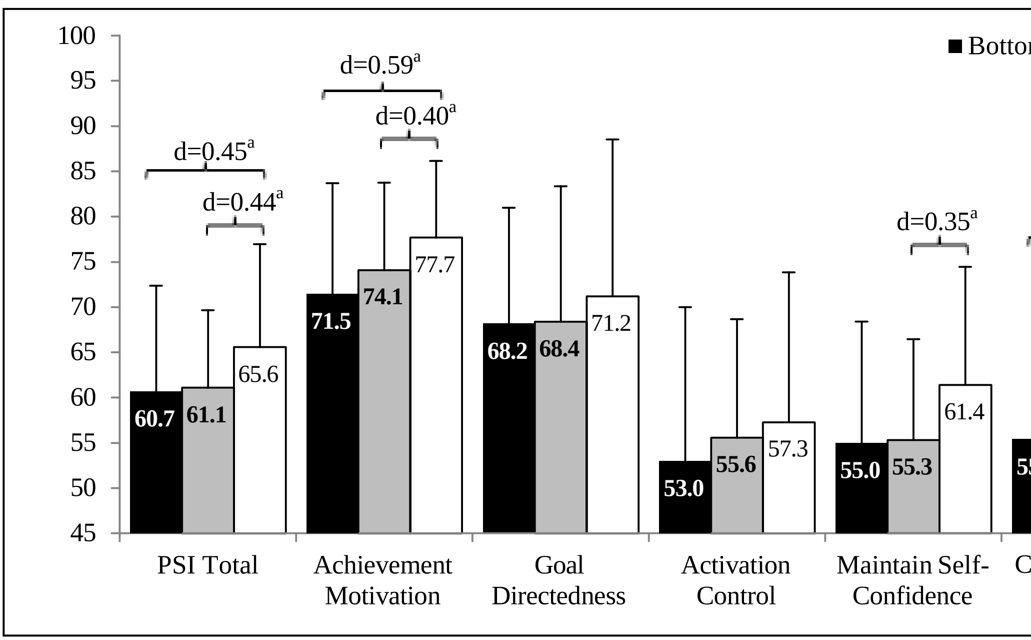
Parameters	Bottom 21 M±SD %	Average 20 M±SD %	Top 21 M±SD %	**ANOVA (p-value) Statistically significant difference** Bottom 21 & Ave. 20	Bottom 21 & Top 21	Ave. 20 & Top 21	Bottom & Ave.
PPP Total	55.3±16.26	57.2±11.82	62.3±13.16	0.91	0.24	0.47	0.13
* Concentration	54.8±16.99	51.8±14.98	59.3±16.38	0.82	0.64	0.30	0.19
* Stress control	58.3±18.26	64.3±11.84	69.3±16.53	0.46	0.07‡	0.57	0.38[a]
* Confidence	52.9±19.01	55.5±15.80	58.3±14.17	0.86	0.53	0.85	0.15
PSI Total	60.7±11.67	61.1±8.59	65.6±11.36	0.99	0.31	0.38	0.10
* Achievement motiv.	71.5±12.21	74.1±9.67	77.7±8.47	0.70	0.13	0.50	0.16
* Goal directedness	68.2±12.82	68.4±14.98	71.2±17.35	0.99	0.80	0.82	0.01
* Activation control	53.0±16.99	55.6±13.08	57.3±16.56	0.85	0.65	0.94	0.12
* Maintain self-con.	55.0±13.42	55.3±11.15	61.4±13.05	0.99	0.23	0.27	0.01
* Concentration	55.4±13.35	57.0±10.56	62.7±12.89	0.91	0.14	0.30	0.09
* Imagery	58.2±14.26	56.1±16.91	63.0±14.97	0.57	0.92	0.34	0.07
IAAF score (Range)	530–896	903–980	981–1099	–	–	–	–

‡ Borderline statistically significant differences ($p \leq 0.10$) [a] Moderate practical significant differences ($d \approx 0.5$) motiv.= mo



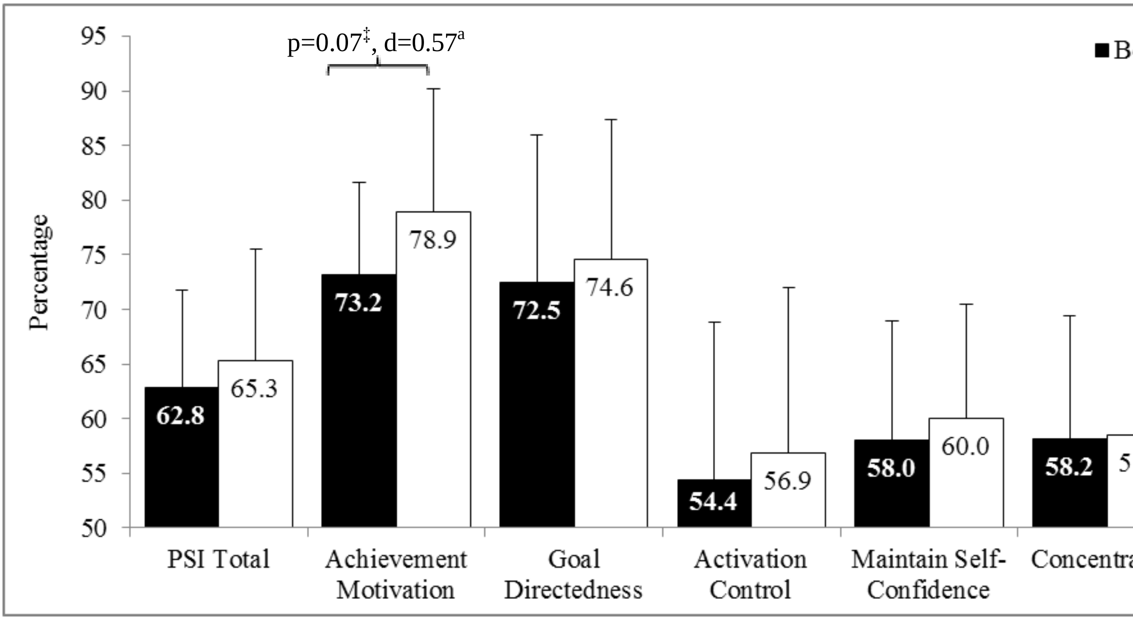
[‡] Borderline statistical significance (p≤0.01)   [a] Moderate practical significance (d≈0.5)

FIGURE 5. **COMPARISON OF PPP SUBSCALE SCORES (MEAN±SD) OF THREE GROUPS OF SPRINTERS**



[a] Moderate practical significance (d≈0.5)

FIGURE 6. **COMPARISON OF PSI SUBSCALE SCORES (MEAN±SD) OF THREE GROUPS OF SPRINTERS**



‡Borderline statistically significant differences ($p \leq 0.10$) [a] Moderate practical significant differences ($d \approx 0.5$)

FIGURE 7. **COMPARISON OF PSI SUBSCALE SCORES (MEAN± SD) OF TWO GROUPS OF MIDDLE- AND LONG- DISTANCE ATHLETES**

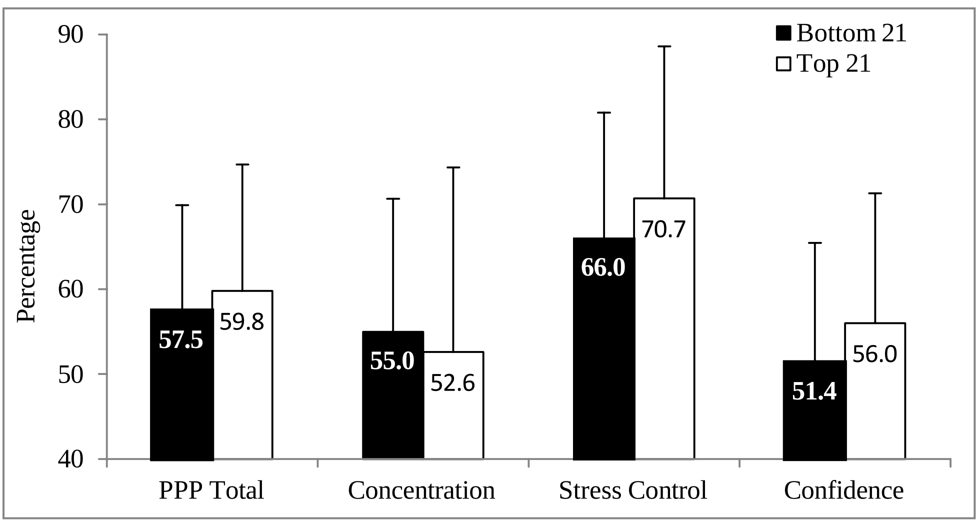


FIGURE 8. **COMPARISON OF PPP SUBSCALE SCORES (MEAN±SD) OF TWO GROUPS OF MIDDLE- AND LONG-DISTANCE ATHLETES**

TABLE 4. **COMPARISON OF PPP, PSI AND IAAF SCORES OF TWO GROUPS OF MIDDLE- AND LONG-DISTANCE ATHLETES**

Variables	**Bottom 21** Mean±SD %	**Top 21** Mean±SD %	**p-value**	**Effect size** (Cohen"s d)
PPP Total	57.5±12.41	59.8±14.91	0.60	0.17
* Concentration	55.0±15.65	52.6±21.77	0.69	0.13
* Stress control	66.0±14.80	70.7±17.91	0.35	0.29
* Confidence	51.4±14.07	56.0±15.30	0.32	0.31
PSI Total	62.8±8.99	65.3±10.22	0.39	0.27
* Achievement motivation	73.2±8.45	78.9±11.25	0.07‡	0.57[a]
* Goal directedness	72.5±13.49	74.6±12.73	0.60	0.16
* Activation control	54.4±14.42	56.9±15.06	0.59	0.17
* Maintain self-confidence	58.0±10.89	60.0±10.43	0.54	0.19
* Concentration	58.2±11.24	58.5±16.78	0.96	0.02
* Imagery	60.4±11.71	63.1±15.65	0.52	0.20
IAAF score (Range)	131–891	896–1066	–	–

‡ Borderline statistically significant differences ($p \leq 0.10$) [a] Moderate practical significant differences ($d \approx 0.5$)

DISCUSSION

Perceived importance of PST

The benefits of mental preparation for training and competition are well-documented (Wann & Church, 1998; Ferraro & Rush, 2000; Jones *et al*., 2002; Pieterse & Potgieter, 2006). Encouragingly, 26% of the athletes in the current sample perceived the development of psychological skills as "very important", whilst 47% perceived it as "important". Weinberg and Gould (2011) emphasised that athletes need to value the importance of PST before they will participate in PST programmes. Although the current results are promising, other factors will also influence whether or not student athletes would participate in such programmes if they were given the opportunity to do so.

Previous consultations with sport psychologist and/or exposure to PST programmes

Only 24% of the athletes reported previous consultations with sport psychologists or exposure to PST programmes. This may be due to limited access to sport psychology experts and a lack of structured PST programmes at high school level due to budget constraints (Hughes, 1990). Van den Heever *et al*. (2007) found that 24.06% of U19, 34.18% of U21 and 43.75% of senior athletes in South Africa had been exposed to sport psychologists during individual consultations or team sessions. Although their results are based on a cross-sectional survey, it suggests that many athletes are exposed to PST programmes during the post-high-school period when many South African athletes attend university.

Alternatively, the current results indicate that the athletes might be resisting PST, despite perceiving it to be important. In this regard, Ferraro and Rush (2000) found that many athletes felt that they were not serious enough about their sport to invest in consultations with a sport psychologist and that they would be wasting their time and money. The excessive time demands (studies, training, competitions) placed on elite student track and field athletes

(Burnett *et al*., 2010), may also contribute to these athletes not making use of sport psychology services. Track and field coaches also reported hindrances, which resulted in the under-utilisation of such services (Wilding, 2009). Financial limitations and the unavailability of sport psychologists were the main reasons cited by coaches as to why they were not implementing PST programmes (Grobbelaar, 2007).

Perceived ability to prepare psychologically for training and competitions

The self-reported "average" (36%) or "below average" (4%) ability of the sample to prepare themselves psychologically for training and competition, coupled with the lack of previous exposure to PST, indicate that coaches and sport psychologists could play a more active role in this regard. According to Gould and Maynard (2009), successful and less successful athletes experienced an increase in stress in the lead-up to important competitions. However, most of the successful athletes worked with sport psychologists to integrate mental training as part of their training programmes in order to deal with these stressors and other unexpected events. Gould *et al*. (2009) noted that sport psychologists no longer only prepare athletes for competitions, but that there has been a shift towards helping athletes to train more effectively by being more focussed.

Need for PST

The coaches in the study of Grobbelaar (2007), reported limited knowledge regarding PST. It is plausible that the athletes in the current sample may not be knowledgeable about PST, as there seems to be considerable uncertainty regarding their own *need for PST*, with 44% of the total sample being "uncertain" of whether they needed PST, whilst 12% stated that they had no need for it. The finding that some athletes did not express a need for PST is not surprising. Kumar and Shirotriya (2010) noted that for some athletes the application of psychological skills is an inherent ability, whereas others need help. Wrisberg *et al*. (2009) found that those athletes with prior experience of consulting sport psychologists were more likely to seek PST than those athletes without prior experience. The female student-athletes were more open to PST than the males. No such gender differences were noted in the current data. The uncertainty regarding a need for PST and the limited previous exposure to PST may indicate a need to educate and expose athletes to a variety of psychological skills.

Sport psychological skills profile

The sport psychological skills profile of the total sample and the five subgroups were reported in Table 2. Collectively, the results indicate poor overall sport psychological skill levels (with mean scores of less than 60% for four of the six PSI-subscales). The remaining two PSI subscales („achievement motivation‟ and „goal directedness‟), yielded acceptable scores (>70%). These results are similar to that of Eloff *et al.* (2011), who observed that student field hockey players scored poorly in all the PSI subscales with the exception of achievement motivation, which yielded average scores. However, normative data on both the PSI and PPP is still needed to interpret these scores accurately.

Although between-group comparisons were not a specific aim of the study, some findings from these results will be discussed. Despite achieving the best athletics performance (mean IAAF scores), the sprinters showed the lowest „achievement motivation‟, „activation control‟ and „self-confidence‟ scores of all the groups. The middle- and long-distance athletes had the lowest „concentration‟ values, whereas the jumpers obtained the best values. The jumpers also recorded the highest „stress control" scores, whilst the throwers had the best „confidence", „achievement motivation" and „activation control" scores. The jumpers and throwers recorded the lowest „imagery" scores, which are in contrast to the findings of Ungerleider and Golding (1991) that field athletes used more imagery and other forms of mental practice than track athletes did. In this regard, the multi-event athletes were the most „goal-directed" group and made greater use of „imagery", whereas their „confidence" levels and ability to „control their stress" levels were the lowest of all the groups.

Within-group comparisons between the sprinters

The Top 21 sprinters obtained the highest mean scores for all the sport psychological skills when compared to the remaining two groups. Practical significant differences of moderate magnitude were observed between the Top 21 and Bottom 21 sprinters for PPP total, stress control, PSI total and achievement motivation, and between the top 21 sprinters and Average 20 sprinters for PPP total, concentration, stress control, PSI total, achievement motivation, maintaining self-confidence and concentration. With regard to the Top sprinters" ability to control their stress levels, Turner and Raglin (1996) found that track and field athletes, whose pre-competition anxiety fell inside their Individual Zone of Optimal Functioning (IZOF), performed better than those who were outside their IZOF.

The achievement motivation differences between the successful and less successful sprinters are in line with Mallet and Hanrahan (2004), who noted that elite athletes were highly driven by personal goals. Self-confidence was identified also as a discriminator between the successful and less successful athletes. Confident athletes conveyed that their belief in their own ability affected their Olympic performance positively, whereas non-confident athletes felt that it affected their performance negatively (Gould & Maynard, 2009). Highly confident track and field athletes also made greater use of imagery, although they did not necessarily have better imagery skills than those athletes with low confidence (Abma *et al*., 2002). Orlick and Partington (1987) observed a relationship between concentration (the ability to focus and deal with distractions), and peak performance during important competitions, whilst refocusing skills allowed track and field athletes to restructure their thinking to prepare mentally for the competitive demands of important competitions (Vernacchia, 1998).

Collectively, the current results confirm the importance of well-developed sport psychological skills in order to excel in sprinting, as there were significant differences between the successful and less successful sprinters regarding stress control, achievement motivation, self-confidence and concentration levels.

Within-group comparisons between middle- and long-distance athletes

Kruger *et al*. (2012) observed that talented adolescent distance runners had significantly better coping skills with adversity, optimal performance under pressure, goal setting and concentration scores than their less talented counterparts. In contrast, the only practical significant difference between the more and less successful middle- and long-distance athletes in the current sample was noted for achievement motivation, where the top athletes scored higher than the bottom athletes, which emphasises the importance of being highly motivated to achieve success in endurance events. A likely reason for achievement motivation being the only distinguishing factor, may lie in the diversity of the middle- and long-distance group, which comprised participants of the 800m, 1500m, 3000m steeple chase, 10km and 21km events. The differences between these events may present varying psychological demands, different usage of psychological skills, as well as different needs with regard to PST.

CONCLUSIONS

The majority of the athletes recognised psychological skills as an important performance factor, but generally, the services of sport psychology consultants were under-utilised. The athletes‟ perceived ability to prepare psychologically for training and competition was average, whereas there was a fair amount of uncertainty regarding their need for PST programmes. Overall, the group scored poorly on most of the sport psychological skills. With regard to the possible role of psychological skills in athletics performance, the more successful sprinters obtained significantly better scores than the less successful sprinters for various psychological skills. The successful middle- and long-distance athletes also had significantly better achievement motivation levels than their less successful counterparts.

Although the cross-sectional design precludes causal inferences, these results substantiate the general belief that superior psychological skills are associated with sport success. Caution should be applied when generalising the current results as the study used an availability sample of university level track and field athletes.

RECOMMENDATIONS

Future studies should investigate why athletes may be reluctant to use the services of sport psychologists and whether or not university level sport programmes make provision for this important performance factor. The development and implementation of PST programmes based on the current findings is recommended. The effectiveness of such programmes in developing psychological skills and enhancing athletic performance also should be researched further.

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ISOKINETIC NECK MUSCLE STRENGTH-RATIOS IN SAGITTAL AND FRONTAL PLANES: MEN AND WOMEN ARE DIFFERENT, BUT AGE DIFFERENCES ARE A MYTH

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ABSTRACT

Strengthening of neck muscles has therapeutic value, but should be done with due cognisance of agonist/antagonist strength ratios. Limited information regarding dynamic neck strength ratios is known to guide rehabilitation. The purpose of the current research was to delineate and compare isokinetic strength-ratio data for flexion/extension and lateral flexion to the non-dominant/dominant side of the neck stratified according to gender and age. Healthy males (n=221) and females (n=231) aged 19 to 69 years were assessed and strength ratios and 95% confidence intervals were calculated. Strength ratios were analysed using ANOVA analysis with Scheffè post hoc tests, to determine whether significant differences existed between gender and age categories. Males had a significantly larger ($p<0.05$) flexion/extension strength ratio than the females (males= 0.63±0.14; females= 0.56±0.16). No significant difference was observed between males (1.03±0.11) and females (1.03±0.12) for lateral flexion strength ratio. No significant differences in strength ratios were observed between age categories within each gender. Isokinetic strength ratios of gender-discriminant age categories presented contribute to the delineation of dynamic neck muscle function. The use of gender-specific isokinetic strength ratios is warranted, but not age specific ratios.

Key words: Neck muscles; Muscle strength; Rehabilitation.

INTRODUCTION

Normal function of the head-neck complex requires effectively integrating the static and dynamic tasks of the neck muscles (Dvir & Prushansky, 2008). Muscle weakness (Portero *et al*., 2001; Ylinen *et al*., 2004; Prushansky *et al*., 2005; Cagnie *et al*., 2007; Pearson *et al*., 2009; Scheuer & Friedrich, 2010), or altered activation (Lindstrøm *et al*., 2011; Lindstroem *et al*., 2012; Schomacher *et al*., 2012; Boudreau & Falla, 2014), leads to a compromise of these static and dynamic tasks and could be associated with pain and/or disability. Strength assessment and rehabilitation of the neck muscles are thus crucial when the neck is injured (Falla, 2004; Dvir & Prushansky, 2008; Jull *et al*., 2008; Elliott *et al*., 2010).

The use of proprioceptive and dynamic-resisted strengthening exercises for the shoulder muscles surrounding the neck, as well as the neck muscle, in the treatment of chronic or frequent neck disorders is supported in literature (Sarig-Bahat, 2003; Vincent *et al.*, 2013). Moreover, the literature shows that neck pain prevention, among the general population, can be achieved effectively through neck strengthening exercises (Linton & Van Tulder, 2001). Although strengthening of the neck muscles has therapeutic value, doing so without due cognisance of the agonist/antagonist strength ratios that exist in the neck, is ill advised. This is because strength ratios, used clinically, indicate the capacity of opposing muscles crossing the joint to co-activate and facilitate dynamic joint stability (Blackburn *et al*., 2000) by reducing angular velocity and range of motion (Lindstrøm *et al*., 2011). Thus, by altering the agonist/antagonist strength ratio from the norm could have consequences for joint stability.

For isometric neck flexion to extension, a strength ratio of about 0.6 among the general population has been reported (Jordan *et al*., 1999; Garcés *et al*., 2002; Lindstrøm *et al*., 2011). Conversely, an isometric ratio of about 1.0 has been reported for the lateral flexors, due to the bilateral symmetry of the neck musculature (Chiu *et al*., 2002; Lindstrøm *et al*., 2011).

Limited information regarding the dynamic functioning of the neck muscles is available because of the large volume of isometric strength assessment methods reported in literature (Portero & Genriés, 2003). Moreover, no standardised method of isometric or isokinetic measurement of neck strength exists. Researchers use a variety of different methods, which lack uniformity and consequently results are incomparable. The use of strength ratios is, however, an attempt to eliminate the influence of the diverse testing methods available.

PURPOSE OF RESEARCH

To address, in particular, the lack of knowledge regarding the neck muscles' dynamic function, some researchers have employed isokinetic dynamometry as an assessment method (Du Toit *et al*., 2003; Du Toit *et al*., 2005; Deslandes *et al*., 2008; Olivier & Du Toit, 2008; Olivier *et al*., 2010). Nonetheless, little is known regarding dynamic agonist/antagonist neck muscle strength ratios across genders and age categories. The purpose of the study reported here was to delineate the isokinetic flexion/extension (F/E) and lateral flexion to the non-dominant/dominant side (LN/LD) strength ratios for various age categories and both genders. Furthermore, statistical analyses were performed to identify significant differences between the generated gender and age categories for the determined strength ratios.

METHODS

Ethical Clearance

Clearance for the study was obtained from the Research Ethics Committee (Human) of the Nelson Mandela Metropolitan University.

Participants

Healthy male (n=221) and female (n=231) participants were sampled through purposive and snowballing techniques. Informed consent was obtained from all participants prior to anthropometrical and isokinetic assessment. To ensure accuracy of the strength ratio reference data generated, outliers (z-score>3) were eliminated from the data set. This resulted in the total number of participants evaluated, determined through the addition of the quantities displayed according to the gender-discriminant age categories, numbered 452.

Anthropometric measurements

The anthropometric variables, height and weight, were measured prior to the isokinetic assessment and, for the sake of completeness, the unique methods used to measure neck girth and length are explained fully.

Neck girth and length

Neck girth and length were measured while the participant sat with the head in the Frankfort plane. Neck girth was measured with a steel tape, which was placed directly superior to the thyroid cartilage and perpendicular to the long axis of the neck. Care was taken not to pull the tape to tight (Norton *et al*., 1996). Neck length was regarded as the distance from the spinous process of the vertebral prominence (C7) to the occipital notch at the base of the skull, as measured with a sliding calliper (Du Toit *et al*., 2003).

Isokinetic neck muscle strength assessment

The equipment used to measure isokinetic strength during flexion, extension and lateral flexion of the neck has been validated and reported on elsewhere (Du Toit *et al*., 2003). A Cybex II isokinetic dynamometer was used to measure concentric torque production during the above-mentioned movements. Testing speed was set at $30^{o}.s^{-1}$, which is similar to speeds used in other studies (Portero *et al*., 2001; Portero & Genriés, 2003). The slow testing speed contributes to the safety of the assessment protocol employed, accommodating the vulnerability of the neck with slow acceleration to peak torque thus avoiding the need for a ramping protocol.

The participants completing a thorough warm-up prior to performing maximal effort repetitions, which enhanced the safety of the assessment protocol employed. The warm-up consisted of active full range of joint motion movements, stretches and submaximal isometric contractions. Additionally, once the participant was correctly positioned in the testing equipment, 6 submaximal, increasing to maximum, warm-up movements were performed against the isokinetic dynamometer. Correct positioning of the participant centred on the alignment of the dynamometer input axis to C7. Other researchers (Portero *et al*., 2001; Portero & Genriés, 2003), have suggested a dynamometer input axis alignment that corresponds to the junction between C7 and T1. C7, however, provided a clearer reference point for alignment and, therefore, it was preferred. The maximum torque produced during 3 maximal effort repetitions was recorded and used for the analysis of the data.

Statistical analyses

Gender-discriminant age categories (Males: M19 to 29, M30 to 39, M40 to 49, M50 to 59, M60 to 69; Females: F19 to 29, F30 to 39, F40 to 49, F50 to 59, F60 to 69), were used to group the calculated data. Possible significant ($p<0.05$) differences between the genders and gender-discriminant age categories were sought by means of ANOVA analysis with Scheffè post hoc tests. The effect size, only of identified significant differences, was determined with the use of eta squared (η^2). Eta squared results were interpreted as follows: $\eta^2= 0.02$ represented a small effect size; $\eta^2= 0.13$ a medium effect size; and $\eta^2= 0.26$ a large effect size. The calculation of 95% Confidence Intervals (CIs) (M ± [S.E.M. x t-crit$_{95}$]), according to the gender-discriminant age categories, were performed to serve as reference data. Statistica software was used to perform all statistical analyses.

RESULTS

Table 1 displays descriptive data according to the gender-discriminate age categories. Males, as a group, were significantly ($\eta^2= 0.35$) heavier and taller than the females. Moreover, they had significantly ($\eta^2= 0.48$) larger neck circumferences, as well as significantly ($\eta^2= 0.42$) longer neck lengths.

TABLE 1. **ANTHROPOMETRIC DATA ACCORDING TO GENDER AND GENDER-DISCRIMINATE AGE CATEGORIES**

Gender	**Age**	**n**	**Weight (kg)** Mean±SD	**Height (cm)** Mean±SD	**Neck Girth (cm)** Mean±SD	**Neck Length (cm)** Mean±SD
Males	All	221	82.98±17.82	175.10±7.38	39.63±3.84	11.92±1.59
	19-29	67	77.47±16.18	176.48±7.25	37.98±2.94	12.15±1.54
	30-39	66	85.13±21.55	174.54±7.28	39.34±4.05	12.44±1.59
	40-49	30	82.17±12.92	172.53±8.71	39.05±3.39	12.13±1.30
	50-59	30	86.95±15.55	175.27±6.85	42.11±3.41	10.89±1.35
	60-69	28	87.73±16.24	175.71±6.56	42.22±3.70	11.04±1.48
Females	All	231	72.82±15.89	161.90±6.53	34.23±2.92	10.82±1.23
	19-29	62	64.57±14.83	164.81±6.23	32.28±2.24	10.99±1.24
	30-39	61	78.21±18.80	160.75±6.44	34.35±3.04	11.09±1.14
	40-49	35	79.42±12.32	160.75±6.53	35.24±2.74	11.05±1.05
	50-59	42	74.68±13.87	161.65±5.58	35.28±2.78	10.62±1.19
	60-69	31	68.72±8.53	159.79±6.87	35.36±2.34	9.97±1.24

TABLE 2. **NECK STRENGTH-RATIO ACCORDING TO GENDER**

	Flexion/Extension			**Lateral Flexion** *Non-dominant/Dominant*		
Gender	n	Mean±SD	95% CIs	n	Mean±SD	95% CIs
Males	219	0.63±0.14*	0.65 0.61	219	1.03±0.11	1.04 1.01
Females	229	0.59±0.16	0.61 0.57	230	1.03±0.12	1.04 1.01

* p<0.05 Males have greater neck strength ratio [small effect size (η^2= 0.017)]

It was found that the F/E ratio was affected by gender; the LN/LD ratio, however, was not (Table 2). The mean F/E ratio of 0.63±0.14 of the males was marginally but significantly (η^2= 0.017) greater than that (0.59±0.16) of the females. The significant difference between the males and females for the measure of F/E ratio is highlighted by the different 95% CIs calculated (Table 2). Males had a 95% CI upper limit for the F/E ratio of 0.65 and a lower limit of 0.61. On the other hand, in the case of the females, the 95% CIs were 0.61 and 0.57. The LN/LD ratio of 1.03±0.11 of the males was similar to the ratio of 1.03±0.12 of the females and no significant difference was observed. Hence, the 95% CIs for males and females were similar.

The agonist/antagonist strength ratios according to the gender-discriminate age categories are displayed in Table 3.

TABLE 3. **NECK STRENGTH-RATIO FOR GENDER-DISCRIMINATE AGE CATEGORIES**

Gender	**Age**	**n**	**Flexion/Extension** Mean±SD	95% CIs	n	**Lateral Flexion** *Non-dominant/Dominant* Mean±SD	95% CIs
Males	19-29	67	0.62±0.13	0.65 0.59	67	1.01±0.11	1.04 0.99
	30-39	65	0.66±0.15*	0.69 0.62	65	1.04±0.10	1.06 1.01
	40-49	29	0.65±0.14	0.71 0.60	30	1.03±0.10	1.07 0.99
	50-59	30	0.57±0.12	0.62 0.53	30	1.02±0.15	1.07 0.96
	60-69	28	0.60±0.15	0.66 0.54	27	1.05±0.10	1.09 1.01
Females	19-29	62	0.65±0.16	0.69 0.61	62	1.03±0.11	1.06 1.00
	30-39	61	0.54±0.14	0.58 0.51	60	1.05±0.12	1.08 1.02
	40-49	35	0.54±0.17	0.60 0.48	35	0.98±0.13	1.02 0.93
	50-59	42	0.61±0.16	0.66 0.56	42	1.05±0.11	1.08 1.01
	60-69	29	0.57±0.11	0.62 0.53	31	1.00±0.11	1.04 0.96

* p<0.05 Males have a significantly larger ratio [medium effect size (η^2= 0.36)]
Note: The differences between the number of observations per gender per age group per test is a

reflection of the fact that not all participants could complete the specific test.

F/E ratios for all age categories were observed in a narrow band ranging from 0.54 to 0.66 and statistical analyses showed that it was unaffected by age amongst males and females. Inter-gender statistical analyses revealed only 1 significant difference between the male and female age categories, which was shown to be a large effect size (η^2= 0.36). This was

between males and females in the age category, 30- to 39-years-old. LN/LD ratios ranged from 0.98 to 1.05 across the gender-discriminate age categories. No significant intra- or inter-gender differences among age categories, with regard to LN/LD ratios, were found.

DISCUSSION

Although isokinetic strength assessment is regarded as the gold standard method for dynamic muscle testing (Dvir, 2004), little research regarding the dynamic functioning of the neck muscles are available (Portero & Genriés, 2003; Olivier *et al*., 2010). The data provided in Tables 2 and 3 give a comprehensive picture of the dynamic agonist/antagonist neck muscle strength ratios across gender and age categories. Isometric ratio data, from literature, show very similar results to the isokinetic ratio data reported in this study.

Among males, isometric F/E ratios ranging from 0.58 to 0.83 have been reported (Jordan *et al*., 1999; Vasavada *et al*., 2001; Garcés *et al*., 2002; Strimpakos *et al*., 2004; Cagnie *et al*., 2007; Lavallee *et al*., 2013). Notably, large scale studies, such as those by Jordan *et al*. (1999) and Garcés *et al*. (2002), have reported isometric F/E ratios of 0.59 and 0.67 respectively, for males over a large age range. With respect to females, Lindstrøm *et al*. (2011) found an isometric F/E ratio of 0.61 among healthy control subjects. Cagnie *et al*. (2007) also found an isometric F/E ratio of 0.63 among healthy women aged 20 to 59 years. Interestingly, a large scale study conducted by Salo *et al*. (2006) reported an isometric F/E ratio of only 0.39 for a sample of 220 females. Based on reported isometric F/E ratio values among females by other researchers, the values range from 0.41 to 0.83 (Jordan *et al.*, 1999; Vasavada *et al*., 2001; Garcés *et al*., 2002; Strimpakos *et al*., 2004; Ylinen *et al*., 2004; Lavallee *et al*., 2013).

In the present study, the dynamic F/E ratio ranged from 0.57 to 0.66 and 0.54 to 0.65, according to the age categories, for males and females respectively (Table 3). The mean isokinetic F/E ratios of 0.63 and 0.59 found in this study, for males and females aged 19 to 69 years respectively, compare well with isometric ratios found in the literature.

Similar isokinetic F/E ratios to those reported here are also highlighted in the literature. Deslandes *et al*. (2008) reported an isokinetic F/E ratio for nine male participants to be 0.61. Among 183 male rugby players, a large isokinetic F/E ratio of 0.70 was reported (Olivier *et al*., 2008). This altered F/E strength ratio was related, however, to the specific requirements of participating in rugby (Olivier *et al*., 2008). Among the general population, the larger extensor strength compared to flexor strength, as indicated by the F/E ratio, reflects the obvious muscle mass differences and the postural role of the extensor musculature (Jordan *et al*., 1999; Cagnie *et al*., 2007; Zheng *et al*., 2013). Moreover, the extensor musculature possesses a mechanical advantage, due to a longer lever arm, compared to the flexor musculature (Peolsson *et al*., 2001).

The significantly larger F/E ratio for males compared to females observed in this study has not been found in other studies (Jordan *et al*., 1999; Peolsson *et al*., 2001; Garcés *et al*., 2002; Cagnie *et al*., 2007). This significant difference shows that females are proportionally weaker in flexion and/or proportionally stronger in extension compared to males. Zheng *et al*. (2013)

noted in their study that individual neck muscle volume proportions were consistent between men and women, except for the longuscapitus, obliquscaptitis inferior and sterno-cleidomastoid muscles. Vasavada *et al*. (2008) also noted gender-differences in neck muscle size. According to the results reported by Zheng *et al*. (2013), it seems plausible that gender-related volumetric differences in the sterno-cleidomastoid muscle (primary bilateral cervical flexor) may be responsible for females being proportionally weaker in flexion compared to males.

The isokinetic LN/LD ratio determined (1.03) for males and females in this study was similar. This ratio corresponded well with previously reported isometric ratios from the literature, which range from 0.92 to 1.04 (Vasavada *et al*., 2001; Chiu *et al*., 2002; Strimpakos *et al*., 2004; Lindstrøm *et al*., 2011). The isokinetic LN/LD ratio results of the present study, therefore, compare well with other isokinetic ratios for the lateral flexors reported in the literature. Portero and Genriès (2003) found an average isokinetic LN/LD ratio of 1.01 for a variety of individuals. Similarly, Olivier and Du Toit (2008) reported an isokinetic LN/LD ratio of 0.99, while Deslandes *et al*. (2008) determined a ratio of 1.00.

It was found that the isokinetic F/E ratios were affected by gender but not by age. The isokinetic LN/LD ratio, however, was unaffected by both gender and age. No significant intra-gender differences among the age categories were observed for either the isokinetic F/E or LN/LD ratios. The consistency of these ratios across age categories suggest that age associated strength decreases equally affect neck flexors, extensors and lateral flexors (Jordan *et al*., 1999; Garcés *et al*., 2002; Lavallee *et al*., 2013).

Pertaining to the isokinetic testing procedure employed, there were the following limitations. The slow testing speed used, combined with the large range of motion, over which testing was conducted, could have affected findings of peak torque if pain was provoked during the assessment. Care was, nevertheless taken during the screening of volunteers to exclude those with current neck pain or recent history thereof.

The results of this study addresses the lack of knowledge pertaining to the dynamic functioning of the neck muscles by delineating and providing, where appropriate, strength ratio reference data through two planes of neck movement. Reference data according to gender can be used successfully in the rehabilitation of individuals with neck muscle weakness, whether using the isometric, concentric or isokinetic modalities.

CONCLUSION

Isokinetic neck strength-ratio data collected and statistically analysed indicated that the use of gender specific strength-ratio reference data is warranted. On the other hand, however, no evidence exists to support the use of intra-gender age specific strength-ratio reference data.

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ROLE OF CURIOSITY AND OPENNESS TO EXPERIENCE THE BIG FIVE TRAITS ON SPORT MEDIA CONSUMPTION BEHAVIOURS

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ABSTRACT

The purpose of this study was to examine the mediation effect of curiosity on the relationship between Openness to Experience (OE) and media consumption behaviours. A total of 657 participants were recruited. Structural Equation Modelling (SEM) analyses were conducted to test the hypothesised relationships and to evaluate the amount of variance captured by a set of observed variables in latent factors corresponding to measurement error. This study found that OE was related inversely to media consumption behaviours of individuals. The negative relationship was mediated by the role of curiosity in generating a positive relationship between OE and media consumption behaviour. The findings of this study are relevant for several considerations, like for novel sport to become successful in the sport industry.

Key words: Curiosity; Big five traits; Openness to experience (OE); Sport media consumption.

INTRODUCTION

Behaviour to 'explore' new knowledge and information is a characteristic of contemporary people (Harvey *et al*., 2007). It has been recognised in the literature for some length of time that psychological traits, such as Openness to Experience (OE) and curiosity, play a major role in inducing exploratory behaviour towards learning and information searching by individuals (Berlyne, 1954, 1960; Rossing & Long, 1981; Day, 1982, Alberti & Witryol, 1994; Driscoll, 1994; Loewenstein, 1994; Reio, 1997; Collins, 2000). OE is the inclination of individuals to pursue a variety of novel and intellectual ideas, and to experience named intelligence, intellectual interests and curious intellect (Farsides & Woodfield, 2003; Lounsbury *et al*., 2003). Curiosity is a critical and prerequisite motive for human exploratory behaviours (Voss & Keller, 1983; Loewenstein, 1994). Sport media consumers are no exception. Recently, the significance of OE and curiosity has been recognised in sport media consumer research (Park & Kim, 2008). Understanding how sport fans collect and learn information is deemed an essential and prerequisite process for any sport team, organisation, or equipment manufacturer. This is because sport consumers first seek out new information about a certain product in order to learn its attributes and benefits, before they actually purchase the product (Lehmann, 1994; Urban *et al*., 1996).

Despite the importance of psychological traits, such as OE and curiosity, little attention has been focused on the effect of such traits on sport media consumer behaviour in the context of mediated sport. A few empirical studies on the psychological traits have been conducted in the field of mediated sport (Fisher, 2005; Park & Kim, 2008), spectator sport (Park *et al*., 2008), and participant sport (Géczi *et al*., 2008). These works provide insightful rationales concerning how OE, curiosity, or both, function in facilitating sport consumption behaviour. However, there is still a lack of knowledge on the inner workings of OE and curiosity, as well as the various roles they play in the consumption of television and the Internet (Park & Kim, 2008).

PURPOSE OF RESEARCH

The investigation of how media is consumed, and the factors influencing sport media consumption, would facilitate an understanding of the unique behaviours in sport. This may provide logical clues, for both researchers and practitioners, to understand how and why sport fans are generated and transformed from non-fans to sport fans and to create new sport fans by understanding and expanding the fan base (Park *et al*., 2010). In this sense, comprehensive research is required regarding which roles the psychological traits play in sport media consumer behaviour. The purpose of this study was to explore how the psychological traits of sport media consumers influence their behaviour. Specifically, the study empirically investigates the relationships between OE and curiosity, and their effects on sport media consumption.

LITERATURE REVIEW AND RESEARCH HYPOTHESES

Openness to Experience (OE) and sport media consumption

OE is defined as an individual's inclination to pursue a variety of novel and intellectual ideas, and to experience named intelligence, intellectual interests and curious intellect (Farsides & Woodfield, 2003; Lounsbury *et al*., 2003). The unique personality of individuals, represented by enduring or iterative ways of how they feel, think and act, is composed of several traits (Park *et al*., 2008). The Big Five model of personality is one of the most widely used and succinct frameworks for classifying and describing personality traits found through empirical research (Goldberg, 1992). The framework consists of five general personality traits: Extraversion; Agreeableness; Conscientiousness; Neuroticism; and OE (John *et al*., 1991). The desire for intellectual stimulation and exposure to various experiences is one of the key facets of OE that fosters academic performance, learning and intrinsic motivation (Kraaykamp & Van Eijck, 2005; Komarraju *et al*., 2009).

People high in openness are "curious, imaginative, willing to entertain novel ideas and unconventional values" (Costa & Widiger, 1994:3). Openness mirrors individual needs to strengthen understanding of oneself, family, friends and society (Finn, 1997), as well as needs that are deemed best satisfied by the variety and richness of mediated experiences offered in film and books (Nell, 1988; Palmgreen *et al*., 1988). In support of this view, OE has been shown to uncover people's preferences for imaginative, as opposed to conventional, forms of entertainment (Dolliger *et al*., 1991). Sport sociologists have viewed sport as a set of specific competitive physical activities based on elements of play, games and contests.

Media reflect the reality of society (Bennett *et al*., 1982). From this perspective, sport media mirror a contemporary sport society, which is structured, goal-oriented, conventional, and expected (McPherson *et al*., 1989). Hence, it is expected that:

H_1: Higher levels of OE will predict a lesser amount of sport media use (television and Internet).

Curiosity and sport media consumption

Curiosity is defined as "a desire to acquire new knowledge and new sensory experience that motivates exploratory behaviour" (Litman & Spielberger, 2003:75). Curiosity is regarded as one of the major motivational factors facilitating human exploratory behaviours in seeking and acquiring new knowledge and novel stimuli in many domains, such as educational, occupational, organisational and recreational settings (Reio *et al*., 2006; Harvey *et al*., 2007; Park *et al*., 2008). Numerous studies in education, psychology and business have confirmed that curiosity is the prerequisite motivator that influences the learning process and information gathering. For example, Fire (1985:19) insisted, "studies that concern the role of curiosity in arousing conflict and its internal cognitive process, in encouraging inquiry, and in fostering motivation, indirectly imply that curiosity may be the factor that stimulates learning". Curiosity is evoked by the level of information or knowledge gap between what people want to know and what they know now (Park *et al*., 2015). Thus, curiosity stimulates individuals to explore various environments or sources of information and knowledge (television or the Internet) to satisfy their curiosity by filling in that gap with the information and knowledge they obtained.

In a sport context, it is believed that individuals would naturally be curious across a variety of situations because of their psychological traits. Therefore, they first examine the role of trait curiosity in the spectatorship of novel sport to depict the transformation of non-fans into sport fans (Park *et al*., 2008). Individuals who are non-fans of sport often develop an interest in or explore sport due to the significant influence of trait curiosity on their interests and behaviours (Park *et al*., 2011). Accordingly, it is plausible that having a high level of curiosity may result in an increase of knowledge and display more exploratory seeking behaviours for mediated sport-related information and knowledge, than those with low curiosity (Berlyne, 1954; Park, 2007; Park *et al*., 2011). Therefore, it is hypothesised that:

H_2: Curiosity will predict the amount of time spent using sport media (television and Internet).

Mediating role of curiosity

OE and curiosity have been identified as key variables affecting sport media consumption. This section examines potential relationships among the constructs, and derives additional hypotheses expecting their associations. According to Komarraju *et al*. (2009), OE refers to a desire for intellectual stimulation and exposure to various experiences. A number of studies have suggested that OE is an important desire in information seeking behaviour, and that it can be a precursor to curiosity (MacDonald, 1995, 1998; Olver & Mooradian, 2003; Kashdan *et al*., 2004; Jackson & Poulsen, 2005). To clarify, Costa and McCrae (1992) found that individuals with high scores on openness are curious about both inner and outer worlds,

and they are willing to entertain novel ideas and unconventional values. Hence, the following is proposed:

H_3: OE will positively influence the level of curiosity.

Given the previous work indicating conceptual relationships amongst OE, curiosity and information and knowledge seeking, it is necessary to examine the inner workings of OE and curiosity, as well as the various roles they play in the consumption of television and the Internet (Park & Kim, 2008). In general, prior literature appears to support the notion that there is a negative relationship between OE and media consumption behaviours and a positive relationship between curiosity and media consumption behaviours (Park & Kim, 2008; Park *et al*., 2010). If OE is positively associated with sport media consumption (television and Internet uses), it is conceivable that the association is mediated by curiosity. Taken together, curiosity may mediate the influence of OE. For example, OE is expected to exert a direct effect, as well as an indirect effect on sport media consumption. Thus, a mediation effect is anticipated in the current model:

H_4: Curiosity will mediate the relationship between OE and sport media consumption (television and Internet).

METHODOLOGY

Participants

A total of 657 undergraduate and graduate students from 3 large urban universities were recruited to participate in this study. Given that, this study utilised Structural Equation Modelling (SEM), which demands a large sample size (Devellis, 2003; Netemeyer *et al*., 2003), 3 universities were chosen to find enough participants. This allowed the opportunity to pursue a more diversified participant pool. Additionally, as sport media consumption behaviours with the use of television (sport network channels) and the Internet were to be measured, university students were deemed appropriate for this study. Students are usually regarded as the generation most sensitive to using the Internet to follow up sport-related information and watch sport networks. The participants included 205 women and 452 men, and the mean age for the total sample was 20.97±3.39 with a range of 37.00.

Instruments

To examine the relationships between OE, curiosity and sport media consumption behaviours, the participants were asked to complete 2 different inventories, as well as media consumption and demographic questionnaires. The following instruments were utilised for this study.

Sport Fan Specific Curiosity Scale (SFSCS)

Park (2007) argued that sport fan-specific curiosity allows individuals to seek out specific situational and intellectual information in order to learn or obtain knowledge about sport, players, sport teams, sport-related products (equipment) or facilities. Park (2007) also insisted that this curiosity would lead people to become involved in various sport fan behaviours and consumption. Park (2007) developed the SFSCS, encompassing various psychological constructs and curiosity theories, to measure cognitive types of sport curiosity with a 3-factor model (specific and general information about sport and sport facilities).

The scale employed questions about media consumption to identify the relationship between sport fans' cognitive curiosity and their behaviours ('When I miss games, I often search for the final results on television, the Internet and/or in newspapers'). Thus, the usage of SFSCS for this study is deemed sound, in that, those having high scores for sport fan-specific curiosity would be more likely to pursue more in-depth cognitive information and knowledge about sport through various media. As shown previously, the aroused curiosity via knowledge gaps would be satisfied by media consumption, such as the internet and television (Park, 2007; Park *et al*., 2015). The items of the scale were rated from 1 (strongly disagree) to 7 (strongly agree), and the SFSCS demonstrated satisfactory levels of reliability and validity (Park, 2007; Park & Kim, 2008).

Openness to Experience (OE) of the Big Five Inventory (BFI)

The BFI was developed to measure efficiently and flexibly the Big Five traits with short phrases. The BFI has been regarded as a valid and good psychometric scale while using comparatively short items, rather than other scales assessing the 5 dimensions (John & Srivastava, 1999). The Cronbach's alphas (a) for the overall BFI ranged from 0.75 to 0.90 (John & Srivastava, 1999). Among the 44-item BFI measure, the 5-item OE is included to examine the relationship between OE and curiosity (John *et al*., 1991). The 5-item OE scale measures the breadth or depth of intellectual interests (John & Srivastava, 1999). The items were measured on a 7-point Likert-type scale.

Sport Media Consumption

To examine sport media consumption, the authors used the duration of television watching (sport network channels) and Internet use, as these 2 have been the most popular media platforms in the literature on sport fan behaviour (Wann *et al*., 2001; Park, 2007; Park & Kim, 2008), for obtaining and measuring information about sport. Duration of watching sport on TV and use of the Internet for sport-related information will represent the level of sport media consumption.

Analysis of data

Before conducting the main analyses, the data was *screened* to establish whether the data reasonably met the critical assumptions for Structural Equation Modelling (SEM), such as normality, linearity and singularity. To assess missing data patterns, cases with missing and non-missing values on each variable were examined to determine if mean differences in other variables were significant. Next, randomly selected pairs of scatterplots using SPSS Graphs were examined to evaluate the linearity of the variables. Furthermore, the determinant of the input matrix was used to detect extreme multi-collinearity or singularity in the data. Finally, multivariate skewness and kurtosis coefficients, to assess the multivariate normality, were applied (Mardia, 1985). These tests were available through PRELIS 2.80 (Jöreskog & Sörbom, 2006).

A Confirmatory Factor Analysis (CFA) was conducted to *evaluate the measurement model* using Mplus 5.2 (Muthén & Muthén, 2008). Following the recommendations of Weston and Gore (2006), χ^2/df, Hu and Bentler's (1999) Comparative Fit Index (CFI), Standardised Root Mean Square Residual (SRMR) and Steiger's (1990) Root Mean Square Error of Approximation (RMSEA) were applied to assess the goodness of fit of the model to the data. Average Variance Extracted (AVE) values were computed to evaluate the amount of variance captured by a set of observed variables in latent factors corresponding to measurement error (Hair *et al*., 2006). For an estimation of scale reliability, a Structural Equation Modelling (SEM) method suggested by Raykov (1997, 2001) was employed to offset limitations of Cronbach's coefficient alpha (Cronbach, 1951). Discriminant validity was assessed by testing χ^2-differences between 2 nested models for each pair of latent factors in which the researchers either constrained the correlation between 2 factors to be 1.0 or allowed the correlation to be free (Anderson & Gerbing, 1988).

Using Mplus 5.2 (Muthén & Muthén, 2008), simultaneous equations to test the *hypothesised model* were performed. The model specified direct paths from OE to second-order Sport Fan

Specific Curiosity Scale (SFSCS), the duration of television watching and Internet use. The model specified the indirect paths from OE through SFSCS, to intention, to the duration of watching television and using the Internet as well.

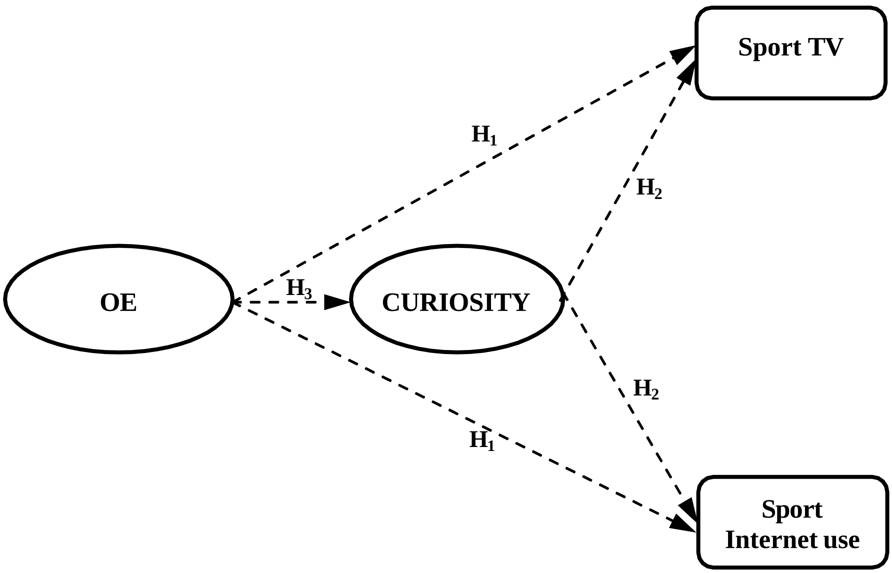

FIGURE 1. **HYPOTHETICAL MODEL**

RESULTS

Evaluation of assumptions

The total of 657 cases was greater than the generally suggested minimum sample size of 200 (Weston & Gore, 2006), and the ratio of cases to observed variables were 55:1, which was adequate for the SEM analyses conducted in this study (Bollen, 1989; Kline, 2005). The data reasonably met all of the assumptions for SEM analyses except the normality assumption.

Scatterplots of randomly selected pairs of variables had a linear shape, which indicated the linearity assumption was reasonably met. Severe multi-collinearity, or singularity, did not exist based on the positive sign of determinant of the input matrix. In addition, group comparisons of observations, with and without missing data, for each variable on the other variables showed significant mean difference ($p<0.05$). However, all observed variables were significantly skewed ($p<0.01$), and 10 of the 12 observed variables revealed significant kurtosis ($p<0.01$). In addition, Mardia's (1985) Normalised Coefficients of both skewness ($z= 49.73$) and kurtosis ($z= 22.54$) were significant ($p<0.01$). Therefore, Satorra-Bentler's (1994) scaling method was applied to reduce the potential problems associated with non-normality.

Measurement model

TABLE 1. **RESULTS FOR CONFIRMATORY FACTOR ANALYSIS (CFA)**

Factors and items	λ	SE	ρ	AVE
Specific			0.84	0.67
I often spend time examining statistics about my favourite team.	0.77	0.02		
When I miss games, I often search for final results on television, Internet and/or in newspapers.	0.83	0.02		
I enjoy discussing sport players, teams, games and events with friends.	0.86	0.02		
General			0.89	0.73
I want to know more about sport.	0.83	0.02		
I am intrigued by what is happening in sport.	0.87	0.02		
I am curious about sport.	0.86	0.02		
Facility			0.77	0.51
I would enjoy visiting a sporting goods factory related to my favourite sport to see how their products are made.	0.56	0.03		
Figuring out how much it would cost to construct a brand new stadium interests me.	0.79	0.02		
I am curious about how big a sport stadium is.	0.77	0.03		
Openness			0.85	0.53
BFI1	0.82	0.02		
BFI2	0.66	0.03		
BFI3	0.65	0.03		
BFI4	0.75	0.02		
BFI5	0.75	0.02		

AVE= Average Variance Extracted SE= Standard Error

As indicated by the Satorra-Bentler scale $\chi2$: (S-B$\chi2$)/df= 195.50/71= 2.75; CFI= 0.97; SRMR= 0.04; and RMSEA= 0.05, the measurement model fits the data well, according to the recommended criteria (Hu & Bentler, 1999). Loadings, reliability coefficients and AVE values are displayed in Table 1.

All factor loadings were positive and significant ($p<0.01$) ranging from 0.77 to 9.89. All reliability coefficients were higher than the recommended criteria of 9.70 (Kline, 2005), and all AVE (Average Variance Extracted) values were higher than the suggested cut-off criteria of 0.50 (Hair *et al*., 2005). Finally, all pairs of constructs showed correlation coefficients that were significantly different from 1.0, indicating discriminant validity (Anderson & Gerbing, 1988). Altogether, these results provide evidence that the instrument was a reliable and valid measure of the constructs of interest.

Hypothesised model

The hypothesised model was analysed to examine the relationship between OE, curiosity and media consumption variables. The hypothesised model specifying the structural relationship among OE, second-order curiosity and media consumption variables fit the data well, χ^2(S-

Bχ^2)/*df*= 314.36/98= 3.21; CFI= 0.95; SRMR= 0.04; and RMSEA= 0.06). All loadings for the first-order curiosity factors on the second-order curiosity factors were significantly different from zero and all standardised loadings were greater than or close to 0.70 (Specific= 0.88; General= 0.80; Facility= 0.69). Path coefficient estimates of the model are shown in Table 2.

TABLE 2. **PARAMETER ESTIMATES FOR HYPOTHESISED MODEL**

Parameters	**Unstandardised**	**Standardised**	**SE**	**t**
Direct effects				
Openness → 2^{nd}-Order Curiosity	0.39	0.29*	0.05	6.34
Openness → TV	-0.24	-0.18*	0.03	-5.21
Openness → Internet	-0.28	-0.13*	0.03	-3.74
2^{nd}-Order Curiosity → TV	0.77	0.75*	0.03	28.92
2^{nd}-Order Curiosity → Internet	1.33	0.81*	0.03	30.21
Indirect effects				
Openness → 2^{nd}-Order Curiosity → Intention to watch TV	0.30	0.22*	0.04	5.82
Openness → 2^{nd}-Order Curiosity → Intention to use Internet	0.51	0.24*	0.04	5.86

The direct path from OE to second-order curiosity was significant (standardised γ= 0.29; SE= 0.05), and the direct path from curiosity to the duration of television watching was also significant (standardised β= 0.75; SE= 0.03). In addition, the direct path from OE to the duration of television watching was partially significant, while only controlling for curiosity (standardised γ=-0.18; SE= 0.03). The indirect path from OE through curiosity to the duration of television watching was significant (standardised γ= 0.22; SE= 0.04). This indicates that the strength of the indirect path from OE through curiosity to the duration of television watching was significantly greater than the direct path from OE to the duration of television watching in the model.

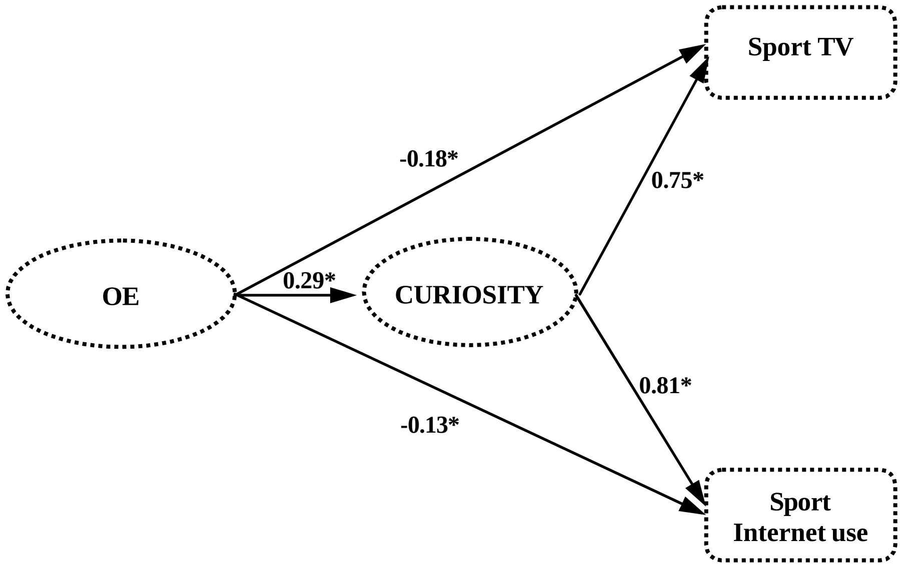

FIGURE 2. **RESULTS OF STRUCTURAL EQUATION MODELLING**

Similarly, the direct path from OE to second-order curiosity, was significant (standardised γ= 0.29; SE= 0.05), and the direct path from curiosity to Internet use was significant (standardized β= 0.81; SE= 0.03). In addition, the direct path from OE to Internet use was partially significant (standardized γ=-0.13; SE= 0.03), while only controlling for curiosity. The indirect path from OE, through curiosity to Internet use was significant (standardised γ= 0.24; SE= 0.04). Therefore, the results supports research indicating that curiosity mediates the relationship between OE and media consumption behaviours for both television watching and using the Internet (Iacobucci *et al*., 2007). The results of the current study show that OE has a significant influence on curiosity, and curiosity has significant impact on both the duration of watching sports on television and using the internet for sport-related information.

The results from the analyses supported the hypothesis that curiosity mediates the effect of OE on media consumption behaviours. Although a direct path from OE to the duration of watching sport on television, and using the internet for sport-related information, were negatively significant, this should not be interpreted as OE and sport media consumption were negatively related. This indicates that the relationship between OE and media consumption is largely explained by the mediator of curiosity, and the unexplained relationships between OE and media consumption are negative after controlling for this mediator. Furthermore, the magnitude of the unexplained negative relationship was marginal, in that, it explains only about 1% of variance in the duration of watching sport on television and using the internet for sport, respectively.

DISCUSSION

The primary purpose of this study was to investigate the mediation effect of curiosity on the relationship between OE and media consumption behaviours, to understand better, how curiosity influences the consumption of knowledge associated with OE. The research found that OE was inversely related to both television viewing and Internet usage. However, these negative relationships were mediated by the role of curiosity in generating positive relationships between OE and media consumption behaviours. The findings of this study are relevant in several regards.

Firstly, consistent with previous studies, this study provides further confirmation of the negative relationship between OE of the Big Five traits and television viewing. While some researchers reported negative effects of OE on television viewing (Finn, 1997; Persegani *et al.*, 2002; Kraaykamp & Van Eijck, 2005), the literature has been quite limited. Research on the relationships is still in its early stage and the results are mixed. Thus, the findings of this study supported the literature regarding the negative relationship and they provide a foundation for subsequent examination of the relationship between OE and media consumption behaviours.

Secondly, this study extended the research on information or knowledge consumption within a new media platform of individuals. While the Internet usage has been a major trend in obtaining information and knowledge during recent years, there have been a limited number of studies that attempt to understand information or knowledge consumption behaviours through the Internet, associated with OE and curiosity (Park, 2007; Park & Kim, 2008). Therefore, it is believed that the findings of this study did not only support the findings of Park and Kim (2008) on the role of curiosity in predicting the media consumptions of individuals, but also expanded the scope of the study on the relationship between OE and curiosity and media consumption.

Thirdly, the main and most interesting finding of this study is that the inverse relationships between OE and both media platforms (television and Internet) became positive through the mediator, curiosity (Table 2). The literature shows that those having a high level of OE would display low television viewing (Finn, 1997; Persegani *et al.*, 2002; Kraaykamp & Van Eijck, 2005). However, the findings of this study demonstrated that if any interesting and informative cues are included that trigger curiosity, participants would be likely to consume or explore media in more detail to gather information and knowledge. Thus, the findings also successfully confirmed that curiosity could be the key for consumers to change their decision-making in non-motivated or even negative situations (Harvey *et al.*, 2007).

By confirming the significant relationships between variables, a useful foundation for practitioners and sport professionals have been provided on which practical implications and new marketing strategies can be based. For example, the findings could be used to argue for sport teams or professionals to trim back their advertising funds spent in traditional mediums, and use those funds to better develop their own promotional materials that are readily visible on team websites and social networking sites. The content can be adapted constantly to organisational changes and trends. Highly identified fans could be targeted separately through the Internet medium much more effectively than an advertisement on a traditional

medium, which is targeted to a wider segment of the market. Additionally, curiosity-arousing Internet content is simple to produce and the message can be controlled exclusively by the organisation. This study suggests that every type of fan, even those with high OE, could be targeted through television and Internet content that stimulates their curiosity.

Furthermore, the function of curiosity as a positive mediator in inverse relationships between

OE and both media platforms, also suggests that sport teams and professionals should be as engaging as possible in their advertising efforts. For example, the use of visual cues should be emphasised and focused on any campaign or promotion in which they are present. This is because the results suggest that curiosity is a positive mediator between OE and television and Internet viewing. It would be possible for them to attract the same consumer to both their broadcasts and live game action. If they can trigger the curiosity of a game attendee, the attendee will be more likely to consume the products and televised or internet-based contents, because curiosity would help the consumer overcome the newness of the products or contents about sport teams (Park *et al*., 2011). The ability to attract a consumer with high OE to these television broadcasts is something that has not been presented in past literature. It could be a very profitable concept for sport organisations who also sell/own the television rights to their team games.

Finally, this mediation effect of curiosity could also be effective in sport education. For example, policy makers in sport and physical education could allow individuals, who are not fans of sport, to experience or learn sport by strengthening their curiosity. Given that those who embrace sport are willing to become sport consumers (Wann *et al*., 2001), they would voluntarily consume various sport-related information with diverse media platforms, such as television and the Internet to satisfy their wants and needs for sport. Therefore, policy makers and/or physical educators need to help individuals learn or experience sport by offering curiosity-arousing media contents that would promote their growth as sport consumers.

Although this study advances sport consumer research, it is not without limitations, which yield opportunities for future research. A key limitation pertains to the generalizability of the student sample. Given that strong effects of curiosity on sport media consumption intentions and a strong predictive capability of the hypothesised antecedents of curiosity were found, the potential for the theoretical and practical application of the framework seems promising. However, the hypothesised framework was examined with a sample consisting of only students. Thus, the current findings can be generalised most validly to the university context. However, the context tested here and the findings are not necessarily generalizable to many other contexts, such as some spectators at professional sport events. Therefore, it would be worthwhile to examine whether the findings presented with this research can be replicated in the context of various types of participant and spectator sport entities.

In summary, this study is the first attempt to investigate a relationship between Openness to Experience (OE) (one of the Big Five traits), and sport media consumption behaviours, and how curiosity, as a mediator, works in this relationship. The current study replicated the findings of previous studies in that OE was negatively associated with both television viewing and Internet use. However, these negative relationships were transformed significantly into positive relationships when curiosity was a mediator. For future research, it would be meaningful to look at the relationship between the different traits of the Big Five and the behaviour of individuals to shed light on how psychological traits work in the transformation of a non-fan into a sport-fan and her/his other sport consumption behaviours (purchases of sport goods or sport event participation).

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EXTENT AND NATURE OF MOTOR DIFFICULTIES BASED ON AGE, ETHNICITY, GENDER AND SOCIO-ECONOMIC STATUS IN A SELECTED GROUP OF THREE- TO FIVE-YEAR-OLD CHILDREN

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ABSTRACT

Attention to adequate motor development is important during the pre-school years, to minimise possible motor difficulties when the child grows older. The aim of this *study was to establish the nature and extent of motor function problems based on socio-economic status, gender, age and ethnicity in 3- to 5-year-old children. A convenience sample of 53 participants, aged 3.0-4.11 years from five pre-schools was assessed with the Movement Assessment Battery for Children-2. A percentage of 11.32% of the group (5 girls; 1 boy) were classified with severe Developmental Coordination Disorder (DCD). These results indicate that the higher socio-economic group (22.73%), girls (15.63%), black children (18.18%) and the three-year-old group (12.50%) had the most children in the severe DCD category. The 3.0-year-old group performed significantly better ($p \leq 0.05$) than the 4.0-year-old group in aiming and catching. White children outperformed black children in fine motor skills and boys outperformed ($p \leq 0.05$) girls in aiming and catching. No statistical significant differences were found between the different socio-economic groups. These results confirm motor difficulties in 3- to 5-year-old children and age and gender differences.*

Key words: Preschool children; Motor development; Developmental Coordination Disorder (DCD); Socio-economic status (SES); Screening; Gender.

INTRODUCTION

Most fundamental motor skills, broadly classified as locomotor, manipulation and stability skills, that are regarded as the building-blocks for more complex skills development (Kirk & Rhodes, 2011), develop between the ages of two and seven years (Malina, 2004). Young children who are identified with difficulties in motor development thus have a lesser ability to master fundamental motor skills (Majnemer, 1998; Chambers & Sugden, 2002). These motor difficulties include milestones in the child's development, which should have been mastered between two and seven years, for example balancing and locomotor skills.

Rosenberg *et al*., *(*2008) report an incidence of 13% motor difficulties among children under the age of three years. Giagazoglou *et al*. (2011) found that 5.4% of Greek children between the ages of four and six years experienced motor coordination problems, as tested with the Movement Assessment Battery for Children-2 (MABC-2). Nikolic and Ilic-Stosovic (2009) tested children with the Bruininks Oseretsky Test of Motor Proficiency (BOT), and reported that 35.44% of the Grade 2 children in Belgrade, Serbia, experienced coordination problems and that 30.12% of the children in the same age group experienced balance problems. A study by Goodway *et al*. (2003) indicated that 77.4%-93.5% of the children in the south of America, with a mean age of 4.9 years, from different socio-economic classes, experienced motor difficulties prior to participating in a nine-week intervention programme, as tested with the Test of Gross Motor Development (TGMD).

Developmental Coordination Disorder (DCD), is defined by the *Diagnostic and Statistical Manual* (DSM-5) of the *American Psychological Association* (APA, 2013), as a noticeable problem in the learning and execution of coordinated motor skills, which interfere with activities of daily living and academic performance of where the onset are already seen in the early developing years. The condition of DCD is not attributed to intellectual disability, visual impairment or any neurological condition affecting movement. According to the APA (2013), the incidence of DCD among school-going children between the ages of five and 11 years worldwide is estimated to be between 5 and 6%, while Gwynne and Blick (2004) report an incidence of 4.2% among five-year-olds tested with the Bruininks Oseretsky Test of Motor Profiency-2 (BOT-2). However, literature still debates the incidence of DCD among school-going children with estimates that vary between 1.8% (Lingam *et al*., 2009) and 6% (Missiuna, 2008; Asonitou *et al*., 2012). The boy-girl ratio of children diagnosed with DCD as noted in the DSM-5, vary between 2:1 and 7:1 (APA, 2013).

Researchers report that socio-economic and cultural differences also play a role in children's motor development (Wright *et al*., 1994; Hadders-Algra, 2000; Uys & Pienaar, 2010). Studies found that children from impoverished socio-economic circumstances usually receive quantitatively less stimulation than children do from better social backgrounds and that this contributes to poorer development (Hadders-Algra, 2000; Goodway & Branta, 2003). Children who are exposed to these circumstances are also subjected to more risk factors that contribute to poorer development. The risk factors that are reported include low birth weight, prenatal exposure to drugs or alcohol, scant or limited prenatal care (Kazdin, 1995). In this regard, Herbst and Huysamen (2000) indicate that children from more fortunate socio-economic circumstances have better fine motor skills, while those from poorer economic circumstances showed better gross motor skills due to the fact that they play outdoors more often and are less exposed to classroom activities. Uys and Pienaar (2010) also found that children with a mean age of 77 months from lower socio-economic circumstances generally performed poorer in gross and fine motor skills than children from higher socio-economic circumstances.

Gender differences with regard to motor development have also been reported. According to several researchers, boys perform better in activities that require strength and speed, like running, jumping and throwing, whereas girls perform better in fine motor activities like figure tracing, balancing activities and activities that require rhythm, such as hopping and skipping (Lefebvre & Reid, 1998; Malina, 2004; Livesey, *et al*., 2006; Shala & Bahtiri, 2011). Pienaar and Kemp (2014) report that overall motor proficiency of boys is better than that of girls at the age of 6.8 years as tested with the BOT-2. These researchers also found that boys performed better with upper limb coordination and strength skills, while girls performed better with manual dexterity and bilateral coordination skills, although no gender differences were found for fine motor integration, fine motor accuracy, balance and dexterity

(Pienaar & Kemp, 2014). There are, however, also studies that reported no gender differences between the gross motor skills of boys and girls (Pollatou *et al*., 2005; Kirk & Rhodes, 2011).

A few studies confirm that ethnicity plays a role in children's motor development (Capute *et al*., 1985; Pienaar & Kemp, 2014). Capute *et al*. (1985) reported that when children were monitored from birth to the age of two years for reaching various milestones, black children reached these milestones sooner than white children. However, Martinek *et al*. (1978) found that the motor development of eight-year-old black children was poorer than that of white children, but that the differences lessened as they grew older. These researchers tested the children with the "Schilling Body Coordination Test" and compared the motor status of children of different ethnical groups and ages. Pienaar and Kemp (2014) further reported that white children in Grade 1 performed significantly better in six of the eight sub-tests, namely fine motor precision, fine motor integration, hand dexterity, bilateral coordination, upper limb coordination and strength subtests of the shortened version of the BOT-2. In turn, the black children performed better in the sub-tests for balance, running speed and dexterity. These researchers, however, ascribed these differences to the mediating role of socio-economic status rather than to ethnicity (Pienaar & Kemp, 2014).

From the above-mentioned studies, it appears that gender, ethnicity and the socio-economic environment, play a role in the nature and extent of motor difficulties. The few studies that report an incidence of motor difficulties among young children (Goodway *et al*. 2003; Rosenberg *et al*., 2008), do indicate motor difficulties among children between the ages of three and five years. There is, however, limited literature relating to the nature and extent of DCD among three- to five-year-old South African pre-school children and also taking into account the role that age, ethnicity, gender and socio-economic status play in such difficulties.

AIM OF THE STUDY

The aim of the study was to determine the extent and nature of motor difficulties among three- to five-year-old children, based on their age, ethnicity, gender and socio-economic status.

METHOD OF RESEARCH

Study population

The study population was selected from 5 different pre-primary schools in the Potchefstroom area of the North-West Province, South Africa, based on availability to participate in the study, taking into account their age, ethnicity, gender and socio-economic status (SES). Three of the schools were situated in less affluent areas of Potchefstroom, while 2 of the schools were situated in areas that are more affluent. Fifty-three children, between the ages of 3 and 5 years, were identified. The children were all assessed with the MABC-2 to determine their coordination status. The children were then divided into 2 age groups according to their chronological ages, namely 3.0 to 3.11 years (n=24) and 4.0 to 4.11 years (n=29). Twenty-one boys (n=21) and 32 girls (n=32) were included representing 2 ethnic groups, namely white (n=20) and black (n=33).

The group was also divided into 2 SES groups, namely low (11 white, 20 black) and high (11 white, 11 black). This division was based on information obtained by means of a demographic questionnaire that the parents/legal guardians had to complete where income categories were given and they had to indicate the combined income level in which they fell. The low socio-economic class was identified when the parent or legal guardian indicated that a government grant or a combined income of R5 500 per month was received. The middle income socio-economic group was identified when the parents or legal guardians had a combined income of between R5 500 to R35 000, while parents or legal guardians were placed in a high socio-economic income group when a combined income of higher than R35 00 per month was indicated (Stats SA, 2010). The middle and higher socio-economic income groups were combined into a higher socio-economic group because of the small numbers of participants.

Inclusion criteria were that the parents or legal guardians had to speak Afrikaans, English or Tswana. Children had to be between the ages of 3.0 to 4.11 years to participate in the study. Criteria that excluded children from participation in the study were if definite mental retardation, autism or any other identified neuro-motor difficulty or dysfunction were suspected.

Measuring instrument

Movement Assessment Battery for Children-2 (MABC-2)

The MABC-2 is a standardised measuring instrument, which was developed and adapted from the MABC by Henderson *et al*. (2007). Children participating in the research had to perform a number of motor tests in a specific manner to determine motor difficulties objectively. The MABC-2 is designed to identify children between the ages of 3.0 years to 16.11 years who are thought to have motor coordination difficulties. Age group 1 (3 to 6 years) of the MABC-2 was used to identify 3- to 5-year-old children with motor difficulties.

The MABC-2 has 8 sub-items divided into 3 main sections, namely fine motor, aiming and catching and balance. Each raw score is reflected in a point score as described in the MABC-2 manual. The number of points is converted to a standard score that is then used to determine a percentile score. A higher standard score obtained by the child indicates better performance and will show a higher percentile score. The cut-off points of the MABC-2 are determined according to standard scores that are interpreted as follows (total and sub-divisions): green (no DCD-status, $\geq 15^{th}$ percentile, total score of 67 and higher, no motor difficulties); yellow (risk of DCD, between the 5^{th} and 15^{th} percentile and standard scores between 57 to 67, at risk for coordination disorder); and red (severe DCD, $\leq 5^{th}$ percentile and standard score of 56 or less). The MABC-2 reflects good reliability for the sub-items separately (r= 0.73 to 0.84) and for the total test score (r= 0.80) (Henderson *et al*., 2007). A qualified Kinderkineticist conducted the assessment at the different pre-schools.

Ethical clearance

Ethical approval for the study was obtained from the Ethics Committee of the North-West University, Potchefstroom campus (NWU-00066-12-A1), as well as the Department of Basic Education of the North West Province. A meeting was held with the various school principals, during which the purpose and protocol of the study were explained. Informed consent was also obtained from all parents/legal guardians prior to the inclusion of the children in this study.

Statistical analysis

The “Statistica for Windows 2012” StatSoft-computer programme package was utilised (StatSoft, 2013) to analyse the data. Data was firstly analysed for descriptive purposes by means, standard deviations (SD) and minimum and maximum values. Frequency tables were used to analyse the DCD status of the group, where the percentages of children that were categorised in each group were indicated. Differences between means relating to the groupings within age, ethnicity, gender and socio-economic status were calculated by using independent t-testing, where $p \leq 0.05$ was accepted as significant. Effect sizes (ES) were calculated to determine the practical significance of the results by dividing the difference between the means of the 2 test occasions by the larger standard deviation (SD). For the interpretations of practical significance, the following guidelines were used: $d \geq 0.2$ indicates a small effect; $d \geq 0.5$ a medium effect; and $d \geq 0.8$ a large effect (Cohan, 1988). Differences were regarded as practically significant if the ES indicated a medium and/or large effect.

RESULTS

For comparison purposes, the 53 subjects that were part of the study were divided based on age, ethnicity, gender and socio-economic status (SES) as reflected in Table 1.

TABLE 1. **NUMBER OF SUBJECTS ACCORDING TO AGE, ETHNICITY, GENDER AND SOCIO-ECONOMIC CLASS GROUPS**

	Age (n)		**Ethnicity** (n)		**Gender** (n)		**SES** (n)	
	3-4 yrs	4-5 yrs	White	Black	Boys	Girls	Lower	Higher
	24	29	20	33	21	32	31	22
Total (N)	53		53		53		53	

N/n= Number of subjects yrs= years SES= Socio-Economic Status

Table 2 provides the results on the distribution of the subjects in each of the different DCD categories. Category 1 (above the 15th percentile) indicated no possibility of DCD in 60.37% of the subjects. Category 2 indicated that DCD of a moderate nature (5 to 15th percentile) was identified in 28.30% of the group, while 6 of the subjects (11.32%) were categorised in the third group (0 to 5th percentile), indicating definite or severe DCD among them.

TABLE 2. **DISTRIBUTION OF DCD SUBJECTS IN GROUP**

DCD category	**Number (N)**	**Cumulative (n)**	**Percentage(%)**
1: No DCD	32	32	60.37
2: Moderate DCD	15	47	28.30
3: Severe DCD	6	53	11.32

N/n= Number of subjects

Table 3 reflects the frequency distribution according to the group in which the subject was placed with regard to his/her DCD status in each age, ethnic, gender and socio-economic group. This analysis indicates that with regard to percentages, the high SES group (n=5; 22.73%) had the highest percentage of children in the severe DCD group, as well as the girls (n=5; 15.63%), black children (n=6; 18.18%), and the 3-year-old group (n=3; 12.50%). The largest percentage of the subjects (52 to 75%) in the different age, ethnic, gender and socio-economic groups were diagnosed with no possibility of DCD.

TABLE 3. **DISTRIBUTION IN DCD CATEGORIES ACCORDING TO AGE, ETHNICITY, GENDER AND SOCIO-ECONOMIC STATUS**

Groups		**No DCD**	**Moderate DCD**	**Severe DCD**	**Total Group**	**Moderate + Severe DCD**
3.0-3.11yrs	(n)	17	4	3	24	7
	%	70.83	16.67	12.50	100	29.17
4.0-4.11 yrs	(n)	15	11	3	29	14
	%	51.72	37.93	10.34	100	48.27
White	(n)	15	5	0	20	5
	%	75.00	25.00	0.00	100	25.00

Black	(n)	17	10	6	33	16
	%	51.52	30.30	18.18	100	48.48
Boys	(n)	15	5	1	21	6
	%	71.43	23.81	4.76	100	28.57
Girls	(n)	17	10	5	32	15
	%	53.51	31.25	15.63	100	46.88
Low	(n)	19	11	1	31	12
	%	61.29	35.48	3.23	100	38.71
High	(n)	13	4	5	22	9
	%	59.09	18.18	22.73	100	40.91

n= number of participants

In addition, independent t-testing was applied to determine the mean values, which the subjects obtained in the MABC-2 and the 3 sub-scales according to age, as well to determine the significance of differences between means (Table 4 to Table 7).

The 3.0 to 3.11 age group performed significantly better than the 4.0 to 4.11 age group in the aiming and catching standard score (22.75±4.46 vs. 19.93±4.14), aiming and catching percentile (66.64±26.57 vs. 52.63±24.78), and the MABC-2 percentile (41.87±26.94 vs. 26.38±20.06) (Table 4). No statistically significant differences occurred between the age groups in the fine motor standard score, fine motor percentile, balance standard score, balance percentile and the MABC-2 standard score, therefore, the practical significant differences that were found are not considered important, although it could indicate tendencies.

TABLE 4. **DIFFERENCES BETWEEN AGE GROUPS: MABC-2 AND SUBSCALES** (N=53)

Variables	**3.0-3.11 yrs** (n=24) Mean±SD	**4.0-4.11 yrs** (n=29) Mean±SD	**Significance of differences** t	df	p-value	d
Fine motor SS	17.75±5.52	16.03±5.85	1.08	51	0.281	**0.30***
Fine motor P	10.10±9.21	8.10±10.52	0.72	51	0.469	**0.20***
Aim-catch SS	22.75±4.46	19.93±4.14	2.37	51	**0.021#**	**0.66****
Aim-catch P	66.64±26.57	52.63±24.78	1.98	51	**0.052#**	**0.55****
Balance SS	31.91±6.48	30.51±6.87	0.75	51	0.452	**0.21***
Balance P	60.66±32.13	54.72±34.26	0.64	51	0.521	0.18
MABC-2 SS	72.87±13.43	66.82±12.42	1.70	51	0.095	**0.48***
MABC-2 P	41.87±26.94	26.38±20.06	2.39	51	**0.020#**	**0.67****

N= number of subjects; SS= Standard Score; P= Percentile; SD= Standard Deviation df= degrees of freedom; #p=≤0.05; d-value≥0.2*; d-value≥0.5**

Table 5 displays the differences between the 2 ethnic groups. The fine motor standard score (p=0.005; d= 0.80) and the fine motor percentile (p=0.006; d= 0.80) of the black and white children indicate statistically and practically significant differences, where the white group (19.55±4.37 and 13.70±12.33), performed significantly better than the black group (15.15±5.85 and 6.16±6.87) respectively. No statistical significant differences were found in the aiming and catching total, balance total and MABC-2 totals. The practical significant differences found are considered less important, but they could serve as indicator of tendencies towards significance.

TABLE 5. **DIFFERENCES BETWEEN ETHNIC GROUPS: MABC-2 AND SUBSCALES** (N=53)

Variables	**White (n=20)** Mean±SD	**Black (n=33)** Mean±SD	**Significance of differences** t	df	p-value	d
Fine motor SS	19.55±4.37	15.15±5.85	-2.89	51	0.005#	0.80***
Fine motor P	13.70±12.33	6.16±6.87	-2.86	51	0.006#	0.80***
Aim-catch SS	21.75±3.65	20.87±4.94	-0.68	51	0.498	0.19*
Aim-catch P	60.17±23.97	58.25±27.97	-0.25	51	0.799	0.07
Balance SS	31.35±4.69	31.03±7.69	-0.04	51	0.867	0.01
Balance P	57.65±30.88	57.26±34.89	0.95	51	0.968	0.26*
MABC-2 SS	72.95±8.82	67.51±14.90	-1.47	51	0.145	0.41**
MABC-2 P	38.00±21.29	30.60±26.12	-0.16	51	0.290	0.04

N= number of subjects; SS= Standard Score; P= Percentile; SD= Standard Deviation df= degrees of freedom; #p=≤0.05; d-value≥0.2*; d-value≥0.5**

Table 6 presents the results of a comparison between boys and girls. Boys and girls only differed significantly in 1 test item namely the aiming and catching standard score (p=0.016; d= 0.69), where boys (23.00±4.77) outperformed the girls (20.03±3.92). No statistically significant gender differences were found in the fine motor percentile, aiming and catching percentile, the balance standard score and the MABC-2 standard score. Once again, the practical significant differences that are indicated in the table are not convincing but may indicate a tendency towards significance.

TABLE 6. **DIFFERENCES BETWEEN GENDER GROUPS: MABC-2 AND SUBSCALES** (N=53)

Variables	**Boys** (n=21) Mean±SD	**Girls** (n=32) Mean±SD	**Significance of differences** t	df	p-value	d
Fine motor SS	17.00±4.50	16.68±6.46	-0.19	51	0.847	0.05
Fine motor P	7.09±6.16	10.26±11.66	1.14	51	0.258	**0.32***
Aim-catch SS	23.00±4.77	20.03±3.92	-2.47	51	**0.016#**	**0.69****
Aim-catch P	66.66±26.24	53.93±25.51	-1.75	51	0.085	**0.49***
Balance SS	32.19±5.61	30.46±7.29	-0.91	51	0.363	0.25
Balance P	60.80±33.36	55.18±33.33	-0.60	51	0.551	0.17
MABC-2 SS	72.19±10.92	67.84±14.28	-1.18	51	0.210	**0.33***
MABC-2 P	36.19±24.23	31.56±24.82	-0.66	51	0.506	0.18

N= number of subjects; SS= Standard Score; P= Percentile; SD= Standard Deviation df= degrees of freedom; #p=≤0.05; d-value≥0.2*; d-value≥0.5**

TABLE 7. **DIFFERENCES BETWEEN SOCIO-ECONOMIC STATUS GROUPS: MABC-2 AND SUBSCALES** (N=53)

Variables	**Lower** (n=31) Mean±SD	**Higher** (n=22) Mean±SD	**Significance of differences** t	df	p-value	d
Fine motor SS	17.96±5.05	15.18±6.30	-1.78	51	0.080	0.50**
Fine motor P	9.77±10.41	7.93±9.28	-0.66	51	0.510	0.18
Aim-catch SS	21.87±4.63	20.27±4.17	-1.28	51	0.203	0.36*
Aim-catch P	63.59±26.05	52.47±25.88	-1.53	51	0.130	0.43*
Balance SS	32.00±5.50	29.95±8.02	-1.10	51	0.275	0.31*
Balance P	59.31±29.82	54.72±37.89	-0.49	51	0.623	0.14
MABC-2 SS	71.83±11.41	66.36±14.90	-1.51	51	0.135	0.42*
MABC-2 P	36.64±25.49	28.82±22.71	-1.15	51	0.255	0.32*

N= number of subjects; SS= Standard Score; P= Percentile; SD= Standard Deviation df= degrees of freedom; #p=≤0.05; d-value≥0.2*; d-value≥0.5**

Table 7 provides the analysis of the results for SES with regard to the MABC-2 and the 3 subscales. No statistical significant differences were found between the lower and higher socio-economic groups, although the fine motor standard score of the 2 groups reflected borderline significant differences (p=0.080; d= 0.50). This indicated that the lower socio-economic group (17.96±5.05) had a tendency towards better performance than the higher socio-economic group (15.18±6.30) in the fine motor total standard score. The standard deviation scores of the groups indicated higher variation in the higher socio-economic group especially in balancing skills which could have influenced their results. The practical significant differences that were found may, therefor, only indicate tendencies, as only a small group of participants were part of the group.

DISCUSSION

The aim of the study was to determine the extent and nature of motor difficulties based on age, ethnicity, gender and SES in children aged three to five years.

A percentage of 11.32% of the total group was classified with severe DCD, and consisted of mainly girls. These results differ from most of the literature relating to the prevalence of DCD between the two genders. From the literature it appears that more boys than girls are diagnosed with coordination problems (with a 2-6:1 ratio) (Pienaar & Lennox, 2006; Asonitou *et al*., 2012). The boy/girl ratio of children diagnosed with DCD also varies from 2:1 and 7:1 according to the DSM-5 (APA, 2013). It is, however, true that mostly clinical studies were reported in this regard, whilst this particular study is population-based, where the ratios are often closer to each other. All six of the children that were classified in the severe DCD group were black, of which five girls and one boy, and five of the children were from the higher socio-economic group.

Cultural differences, where the education of boys is often regarded as more important than that of girls, could perhaps be regarded as a possible explanation. In this regard, Malina (2004) reports that cultural conditioning for gender specific roles starts at a young age; that boys and girls are brought up differently; and that at the age of three discernible differences start to become noticeable between the genders. Walter (2011) also reported that girls are expected to perform household tasks from a young age, while boys are encouraged, by their parents and peer group, to participate in more challenging physical activities, which can contribute to their more advanced motor skills. South African children who grow up in high socio-economic circumstances are often encouraged to play indoors for safety reasons (Pienaar, 2009). This includes engaging in technological games rather than in physical activity (Walter, 2011). In addition, they could have been placed in day-care facilities while their parents have to work. Opportunities for physical activities that contribute to gross motor development may have been restricted in this way, which could have contributed to the higher DCD classification in this group.

The literature reported that the incidence of DCD among school-going children between the ages of five and 11 years is estimated to be 5 to 6% on a worldwide scale (APA, 2013). Cairney *et al*. (2005) reported an incidence of 5 to 9% among children aged nine to 14 years diagnosed with DCD, while Gwynne and Blick (2004) reported a DCD incidence of 4.2% among five-year-olds in Australia. The present study is representative of different ethnic groups and cultures, genders and socio-economic status, which may all be contributory factors to the higher incidence that was found. This also confirms the results of the study of

Uys and Pienaar (2010). South Africa is regarded as a low to middle income developing country where there are many challenges facing the motor development of children (Le Roux, 2013).

In the present study, none of the white children were classified in the severe DCD group, while 18.18% black children were. A study by Pienaar and Kemp (2014) also reported that more six-year-old white children were categorised in the average motor proficiency category (69.27 vs. 38.98%) than black children, where more black children (58.73%) were classified in the below average motor proficiency category. 22.73% of the children in the higher socio-economic group compared to 3.23% in the low socio-economic group were classified in the severe DCD category. Although speculative, a possible reason might be that the parents of white children are more aware of the importance of their child's motor development and are subsequently more involved in their development and spend more time playing with them while cultural influences have a bigger role to play in black families.

Booth *et al*. (1999) reported that fundamental movement skills development are more related to socio-economic circumstances in girls than in boys. In the study of Booth *et al*. (1999), socio-economic conditions played a role in the motor development of girls aged four to 10 years, while the effect of socio-economic conditions were not as prevalent among boys (Booth *et al*., 1999). Uys and Pienaar (2010) also reported that children between the ages of four and 71 months in the low socio-economic group generally performed poorer than the children from a higher socio-economic group did when the two groups were analysed separately as tested with the "Peabody Developmental Motor Scales-2". In an earlier study on a randomly selected group of children between the ages of 10 and 12 years in the North-West Province of South Africa, an incidence of 36.4% severe DCD was found (Pienaar, 2004). Recommendations in this study suggested the norms in the test battery (MABC 1st version) needed to be adjusted in order to make the test battery more valid for the developmental challenges that children face in developing countries.

These current results indicate that there are differences between the various ages and genders regarding the nature of motor difficulties. The results show that 3.0- to 3.11-year-olds performed significantly better than 4.0- to 4.11-year-olds in aiming and catching, as well as in the MABC-2 percentile scores achieved. These results differ from Gallahue and Ozmun's age appropriate developmental phases, which indicate that children's development ought to improve progressively with increasing age (Gallahue & Ozmun, 2006; Pienaar, 2012).

Large variations, as can be seen in the standard deviations that are reported, were, however, found in the motor development of both the younger and older age groups, which is characteristic in children of this age group (Malina, 2004; Gallahue & Ozmun, 2006), and which might have contributed to the differences that were found. In this regard, Malina (2004) reported that the sequence of development in young children is similar, but that the attainment of motor milestones indicates large inter-individual age-associated variation. The early developmental phase is characterised by variation in motor development, which does not necessarily reflect a delay (Malina, 2004). The small number of children who were compared could also have influenced the results, while the children's performance on the day of testing might also have been influenced by how they felt (Malina, 2004). Another reason might be that parents could become less involved in their children's development as their children grow older.

Timmons *et al*. (2007) reported that the level of physical activity of pre-schoolers is comparable to the amount of time their parents spend with their children doing physical activities. The same researchers also suggested that the more physically active children are, the better their motor development become. It would thus appear that the more involved parents are with young children's play and development (games, cycling), the better the child's motor development will be. However, Livesey *et al*. (2006) found that five-year-old Australian children performed poorer than four-year-olds in ball skill tests, although the four-year-old group was not representative of all the different areas (suburban and urban). Livesey *et al*. (2006) furthermore found that the older children in the three age groups (three- to five years) performed better, as tested with the MABC-2 test, in hand dexterity and balance skills as they grew older.

Minor differences were found between fine motor skills in white and black children. A few researchers also confirmed that ethnic origin played a role in the motor status of children (Martinek *et al*., 1978; Capute *et al*., 1985). Martinek *et al*. (1978) found that eight-year-old black children's motor development lagged behind that of white children, but that the differences became less with age. On the other hand, Capute *et al*. (1985) monitored children as they reached various milestones and found that black children reached their early developmental milestones (roll, sit, stand and walk), sooner than white children. Pienaar and Kemp (2014) also found that white children in Grade 1, in the North-West Province of South Africa, performed better with fine motor precision and fine motor integration skills than black children. These researchers, however, ascribed the differences to socio-economic rather than to ethnic differences.

Statistically significant differences were found between the aiming and catching skills of the boys and girls in this study. These results concur with those of other researchers, which indicate that boys performed better with manipulation skills (Goodway *et al*., 2003; Livesey *et al*., 2006; Shala & Bahtiri, 2011; Pienaar & Kemp, 2014). Livesey *et al*. (2006) report that three- to five-year-old boys in Australia performed significantly better in the ball-rolling skill, as tested with the MABC-2. Pienaar and Kemp (2014) found that the overall motor proficiency level of boys was better than that of girls at the age of 6.8 years, tested with the BOT-2. The boys also performed better in upper limb coordination and strength skills, whereas girls performed better with hand dexterity and bilateral coordination skills. However, they did not report any gender differences relating to fine motor integration, fine motor accuracy, balance, running speed and dexterity.

The study of Livesey *et al*. (2007) reported no gender differences in gross and fine motor skills. Four- and five-year-olds boys and girls did not differ on placement of coins, catching and throwing of beanbags, heel-toe walking and rope-skipping skills. Goodway *et al*. (2003) also reported no gender related differences among pre-school children in locomotor skills. Pollatou *et al*. (2005) found no gender differences in five of the six skills tests of the TGMD-2 among pre-schoolers, with the exception that girls did better in the sliding skill than boys. These studies support the results of the present study where no differences were found between the genders in balance and fine motor skills.

Wright *et al*. (1994) reported that socio-economic and cultural differences did play a role in the motor development of children. However, no differences were found between socio-economic groups in their study. This differs from other research that indicated that children from lower socio-economic classes performed poorer than children from higher socio-economic classes (Uys & Pienaar, 2012). Uys and Pienaar (2012) found that children from a higher socio-economic class performed better in fine motor skills. The results of the present study indicate that children from the lower socio-economic group obtained higher, although not significantly higher mean values ($p \geq 0.05$) for balancing and object manipulation skills. A possible reason for these slight differences could be that the effect of the different socio-economic circumstances might not be so significant at a young age. However, the findings of Malina (2004) indicated that the influence of social variables decreases with an increase in age in throwing skills. The lower socio-economic group of the present study constituted mainly black children (20 out of 31). Capute *et al*. (1985) indicated that from birth to the age of two years, black children reach their gross motor milestones (sit and crawl) faster than white children do.

The findings of this study must be considered against the background of the limitations that were present and, therefore, generalisation of the findings has to be done with caution. Since this study focused on children of a very young age, their participation might have been influenced by numerous factors, such as the unfamiliarity of the situation, which might have influenced their motivation to do their best. The results were furthermore obtained from a small number of children and because of the young age of the group, considerable inter-variation in development was noted.

Malina (2004) indicated that the early developmental phase is characterised by considerable variation in motor development that does not necessarily reflect delays. Therefore, it is recommended that similar research be undertaken on a larger number of children of the same age group to confirm the results and the tendencies that were reported based on practical significance. Socio-economic comparisons were based on broad income levels only and subsequently, did not take other indicators, such as education of the parents into account, which could also have influenced the results that were obtained.

It is recommended that similar research on young children should consider factors, such as the education of the parents and rearing influences. The recommendations of experts, namely that children should only be diagnosed with DCD after the age of five years (although the MABC-2 can, in fact, identify DCD from the age of three years), as well as recommendations regarding the interpretation of the results of this study, need to be taken into account. This is especially important for further research relating to the prevention and early identification of the incidence of DCD.

PRACTICAL IMPLICATIONS

Early screenings for motor difficulties that can be indicative of possible DCD are important. These results are important for educators, day care mothers and professionals dealing with the motor development of children such as occupational therapists and Kinderkineticists, to address the problems as early as possible. Ignorance and lack of recognition of motor functioning and motor learning difficulties can be addressed by workshops that are presented to parents of young children, enabling them to recognise when their children require help and to make them aware of the importance of obtaining professional support for their children as soon as possible.

CONCLUSION

This study established definite motor difficulties among a noteworthy percentage of children between the ages of three- and five years in different age, ethnic, gender and socio-economic groups. This emphasises the importance of participation in age-appropriate motor development programmes, which can serve a preventative purpose for motor difficulties that might develop early. The fact that three- to five-year-olds experienced motor difficulties further underlines the importance of identifying these children early with subsequent timely intervention or support to prevent the difficulties from becoming ingrained problems that have long-term implications for their quality of life. Motor problems are modifiable risk factors in the development of young children that can be treated successfully once identified.

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WILLINGNESS OF SPORT FANS TO PARTICIPATE IN SOCIALLY RESPONSIBLE COMMUNITY PROGRAMMES OF PROFESSIONAL SPORT ORGANISATIONS

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ABSTRACT

Corporate Social Responsibility (CSR) has gained increased research interest in recent years. It has evolved globally from a charitable activity into a strategic tool for organisations to protect their reputation, develop brand loyalty and foster competitive advantage. The aim of this study was to develop and empirically test a model to explain the willingness of sport fans to engage in CSR community programmes of professional sport. A model was developed, which proposed that willingness to participation was affected by 4 attitudinal and cognitive variables: fan identification; perceived relevance of the programme; attribution of motives by community members; and attitude toward social responsibility of professional sport. Data were compiled and the model was empirically tested. The 4-variable model explained 61.7% of the variance in the willingness of community members to participate in socially responsible programmes of professional sport. Social demographic differences were explored. Regression analysis revealed that all the hypothesised effects of the independent variables, except altruistic attribution of motives of professional sport on willingness to participate in CSR programmes, were supported.

Key words: Corporate social responsibility; Sport fan; Professional sport; Programmes.

INTRODUCTION

Corporate social responsibility (CSR) is defined as “the continuing commitment by business to behave ethically and contribute to economic development while improving the quality of life of the workforce and their families, as well as of the local community and society at large" (World Council for Sustainable Development, 1999). It has gained increased research interest during the past two decades (Dhurup, 2012). While CSR involves a broad range of issues related to the role, position and function of business in contemporary society (Jonker, 2005), the seminal theme of CSR is that organisations have responsibilities beyond profit maximisation (Carroll, 1979; Moir, 2001). Viewed initially as a charitable or philanthropic activity, CSR has evolved globally into a strategic tool for organisations to protect their reputation, develop brand loyalty and foster competitive advantage (Babiak & Wolfe, 2006). The importance of CSR has risen to the forefront of concern of business communities in

North America (Zwetsloot, 2003; Waddock, 2004). Similarly, CSR is recognised as "an issue of critical importance in Australia's business community" (Parliamentary Joint Committee on Corporate and Financial Services, 2006, p. xiii). In a parallel fashion, the importance of CSR is gaining increasing emphasis in the sport industry around the world.

CSR programmes of professional sport have advantages that organisations in other industries do not have. Firstly, the essentially free and vast media exposure professional sport receive can help enhance the awareness of the social concern they tackle. Secondly, their wide appeal to a diverse sport fan base means the message they send out can be conveyed to otherwise difficult-to-reach populations. Thirdly, their close emotional and psychological connections to fans create the possibility of significantly shaping the opinions of their fans toward the social concern they address.

As a result of these advantages, professional sport is believed to have greater effects in providing inspiration than other businesses in areas, such as education and health care for children, health and exercise, concern for the environment, and social/cultural enrichment (Headlee, 2006). Currently, almost all professional sport in the United States of America have a community outreach department or community programmes (Robinson, 2005). Australian professional sport is also actively involved in CSR community programmes. For example, the Western Bulldogs Football Club, an Australian Football League (AFL) club located in the western region of Melbourne, has four categories of community programmes addressing a range of social concerns the local community faces, from diabetes and water saving to education and community cohesion issues.

While the literature on CSR is extensive, a large body of this literature has focused on the relationship between CSR practices and their economic outcomes and commercial benefits to the delivering organisations (Peloza, 2006; Smith & Westerbeek, 2007; Walters & Chadwick, 2009). Very little research has been conducted to examine how the community receives social outcomes and benefits of CSR programmes (Margolis & Walsh, 2003). The lack of research in this area may not be a problem for business companies whose most predominant form of corporate community partnership, as Zappalá and Cronin (2003) found in a survey of the top 100 companies in Australia, was cash donations.

It is, however, very unfortunate for professional sport. The engagement of professional sport in CSR community programmes is usually more dynamic and hands-on than business organisations, because of its wide appeal and media exposure advantages. They are usually deeply involved with the design and delivery of their CSR community programmes rather than just cash donations (Carroll, 1999). Consequently, it is of paramount importance for professional sport to understand the effectiveness of CSR programmes, not just in terms of their economic outcomes and commercial benefits, but, perhaps more importantly, their social benefits. As mentioned previously, in most CSR community programmes, the social benefits are delivered through the participation of the targeted community.

PURPOSE OF RESEARCH

The aim of this study was to propose and empirically test a model to explain the willingness of sport fans to participate in CSR community programmes of professional sport. Drawing on sport fan behaviour and CSR literature, a model is proposed (Figure 1) to explain why sport fans participate in CSR programmes of professional sport. The model posits that willingness to participate in these programmes are affected by 4 variables: fan identification; the perceived relevance of the social causes or concerns the programmes address; attribution of motives of the involvement of professional sport in these programmes; and the attitude of sport fans toward CSR of professional sport. A discussion of each of the variables follows and various hypotheses will be proposed.

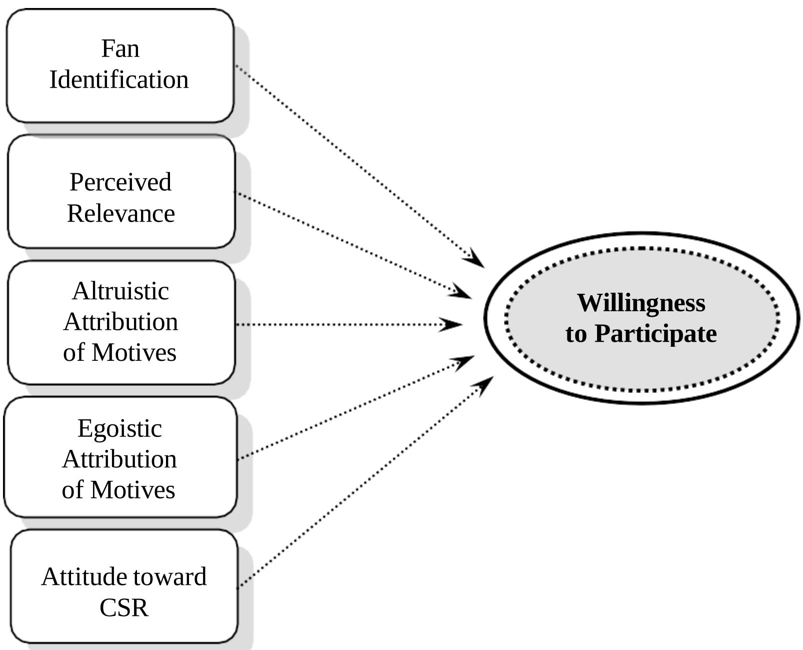

FIGURE 1. **MODEL: PARTICIPATION IN SOCIALLY RESPONSIBLE COMMUNITY PROGRAMMES OF PROFESSIONAL SPORTS**

Fan identification

Fan identification has its theoretical roots in social identity theory (Fink *et al*., 2002) and is defined as the "degree to which fans' relationship with the team contributes to their social identity" (Mahony, 1995:12). It shows the emotional and psychological connections sport fans have with a sport team. It is, perhaps, the most salient indicator of various attitudes and behaviours, associated with the sport team; sport fans display (Sutton *et al*., 1997).

Studies on fan identification are extensive. Empirical studies have repeatedly found that sport fans with high levels of fan identification show a tendency of high levels of involvement with the team. For example, fans were found to attend more games (Murrell & Dietz, 1992), to know more about the players and history of the teams (Wann & Branscombe, 1995), and to be more likely to buy licensed sport merchandise of the team on the Internet (Zhang *et al*., 2006). Moreover, research has found that the support of the fans for their team can be transferred to a third party. For example, Madrigal and Howard (2000) and Zhang *et al*. (2005) found that sport fans with high levels of fan identification were more likely to purchase the team sponsors' products because they were viewed as supporters of the team.

In the light of the impact of fan identification on sport fans, it is expected that fan identification will affect willingness to participate in CSR community programmes. Fans with high levels of identification are likely to view a CSR programme as the opportunity to get involved with the team and, therefore, to be more willing to participate. Therefore, hypothesis 1 is proposed as follows:

Hypothesis 1: Fan identification has an effect on the willingness of sport fans to participate in the CSR programme of a professional sport club.

Perceived relevance of the programme

In CSR literature, especially cause-related marketing (CRM) literature, the relationship between causes and consumers continue to attract interest from researchers. For example, Lafferty (2007) found that consumers responded more positively when the cause was considered to be more important to them. Bhattacharya and Sen (2003) suggested that consumers were drawn to a CRM campaign, because they perceived the cause relevant to them. Gupta and Pirsch (2006) found that consumer-cause congruence, which is similar to cause-relevance, had a positive effect on the attitude of consumers toward the company-cause alliance and purchase intent. Grau and Folse (2007) found that consumers with a high level of cause involvement were significantly likely to participate in a CRM campaign as opposed to those with a lower level of cause involvement.

In this study, perceived relevance of the programme is defined as the degree to which sport fans find the social cause or issue the programme addresses to be personally relevant to them. Personal relevance is the level of perceived importance and/or interest evoked by a stimulus within a specific setting (Antil, 1984). Each of the CSR community programmes is a stimulus, because these programmes are designed to address specific social causes or issues.

The variety of CSR community programmes bears different levels of relevance to individual sport fans because personal relevance is based on inherent needs, values and interests (Zaichkowsky, 1985). For example, a sport fan would be more willing to participate in a CSR community programme that addresses diabetes if s/he has suffered or witnessed a close friend suffering from the disease. Therefore, it is expected that sport fans who found a programme to be more personally relevant should more willingly participate in the programme relative to those who found it less relevant. In this regard, the following hypothesis is formulated:

Hypothesis 2: Perceived relevance of the programme has an effect on the willingness of sport fans to participate in the CSR programme of a professional sport club.

Attribution of motives

Attribution theory has been employed successfully to a variety of situations to explain how people make inferences about the behaviours of others (Folkes, 1984). Sport fans make inferences about the motives of professional sport for their participation in CSR community programmes. In turn, these inferences could affect their intention or behaviour of actually participating in these programmes.

Based on the basic distinctions in the literature between egoistic and altruistic motivations (Bendapudi *et al*., 1996), the intentions of professional sport to provide CSR community programmes can be grouped into egoistic and altruistic motives. Altruistic motives are to improve the welfare of others, also called other-centred motives. Some sport fans may, for instance, view the participation of a sport club in CSR community programmes as improving the welfare of the community and they really want to give something positive back to the community. Others may infer that the motives are egoistic, or are of self-interest, because professional sport clubs often are considered as existing for profit. Their CSR community programmes, therefore, may be viewed as nothing more than a way for attaining additional revenues (attracting more members and selling more tickets).

Empirical studies in business literature have found that the attribution of motives of consumers for a company's CSR involvement can influence the consumption intentions and behaviours of consumers. For example, perceived motives for CSR was found to have an effect on consumer purchase choice (Barone *et al*., 2000) and purchase intention (Ellen *et al*., 2006). The afore-mentioned argument and the findings of empirical studies lend support to the prediction that how sport fans perceive the motives of professional sport for CSR involvement will affect their willingness to participate in CSR community programmes. Sport fans who perceive the motive for CSR to be mainly altruistic will be more willing to participate. On the other hand, sport fans who perceive the motive for CSR to be mainly of self-interest will be less willing to participate. These predictions are hypothesised as follows:

Hypothesis 3: Altruistic attribution of the motives of professional sport for participating in CSR community programmes has a positive effect on sport fans regarding their willingness to participate in the programmes.

Hypothesis 4: Egoistic attribution of the motives of professional sport for participating in CSR community programmes has a negative effect on sport fans regarding their willingness to participate in the programmes.

Attitude toward CSR of professional sport

Ajzen and Fishbein (1977) indicated that while attitude-behaviour consistency is applicable under most circumstances, attitude is a more accurate predictor of behavioural intention than of the actual behaviour. It is expected that the attitude of sport fans toward CSR of professional sport will have an effect on their willingness to participate in these programmes. Sport fans that have a positive attitude toward CSR of professional sport are more likely to participate relative to those who have a negative attitude. The following hypothesis is thus formulated:

Hypothesis 5: The attitudes of sport fans toward CSR of professional sport have an effect on their willingness to participate in the programmes.

In addition to the model testing, it is also important to consider the differences in all five variables based on social demographic variables. It should be noted that the attribution of motives is viewed as one variable in the theoretical model but two (egoistic and altruistic attribution), variables in the empirical model. Social demographic variables have been found to affect attitudes and behaviours of sport fans in a variety of settings and situations (Armstrong, 2002; James & Ridinger, 2002). In this study, gender and religious affiliation are considered.

METHODOLOGY

Ethical considerations

The ethics process of the Human Research Ethics Committee of Victoria University (Melbourne) was followed and ethical clearance (HRETH 08/194) was obtained. Ethical considerations such as participants' right to anonymity, confidentiality, privacy or non-participation, among others, were adhered to during the process of collecting the data.

Sample and procedure

Non-probability sampling technique, namely convenience sampling, was used in the current study. Convenience samples involve selecting sampling units on the basis of where and when the study is being conducted (Bradley, 2007). In this study, a web-based questionnaire was used to collect data from undergraduate students enrolled in sport related courses in a large university in Australia. Data were collected from the students who identified themselves as fans of professional sport clubs.

A fan is described as a keen sport follower who is motivated by the performance and achievement of a favourite team (Robinson *et al*., 2005). For the purpose of this study, their role as sport fans was of relevance. An e-mail with a link to the questionnaire on 'Surveymonkey.com' was sent to the participants. The e-mail explained the purpose of the study and invited the sport fans to participate in the study.

Data were collected from 386 participants. Ten questionnaires were discarded because they were incomplete. Hence, data captured from 376 completed questionnaires were analysed. Of the 376 participants, 33.8% (n=127) were females and 66.2% (n=249) were males. Approximately 36% (n=134) of the participants indicated that they had a religious belief.

Measurement instrument

Arising from the literature study, a questionnaire was developed. The initial questionnaire was pre-tested for content validity by a panel of experts consisting of sport management academics, as well as university students prior to the collection of data. Omissions and modifications were made to some of the items in the questionnaire based on their feedback. All items relating to the willingness of sport fans to participate in socially responsible community programmes were measured on a 7-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree). The reliabilities of all the scales used range from Cronbach's alpha of 0.83 to 0.94, which were much higher than the cut-off value of 0.7 suggested by Nunnally (1978).

Fan identification was measured on a 4-item scale, which was used in a study conducted by Zhang *et al*. (2005). These fan identification items showed good reliability in previous studies with university students (Kwon & Armstrong, 2002; Zhang *et al*., 2005). A sample question reads, “I feel a sense of ownership for the team”. In the present study, a Cronbach’s alpha of 0.94 was found for the scale.

A 5-item scale adapted from previous research by Maheswaran and Meyers-Levy (1990), measured the perceived relevance of the programme. The items measure whether the social cause the CSR community programme supported is important and relevant to the participants. A sample question read, “Community effort to fight diabetes does matter a great deal to me”. A Cronbach’s alpha of 0.86 was found for this scale.

Altruistic attribution of motive was measured by 3 items with a Cronbach’s alpha of 0.88 and egoistic motives by 2 items with a Cronbach’s alpha of 0.83. Three items with a Cronbach’s alpha of 0.93 measured the attitude of sport fans toward CSR of professional sport. Willingness to participate in CSR programme by sport fans was measured by 4 items with a Cronbach’s alpha of 0.88.

Analysis of data

For the purposes of this study, a linear regression and Multivariate Analysis of Variance (MANOVA) statistical procedures were utilised. To test Hypotheses 1 through to 5, a linear regression was conducted to investigate how the model explained the variance in willingness to participate in CSR programmes of professional sport and how each of the variables performed. A series of MANOVAs were employed to examine whether there was a group difference based on the gender and religious belief of participants. If MANOVAs found significant differences between the gender and religious groups, a follow up of univariate ANOVAs was conducted to examine if there were significant differences among each of the 5 variables between the groups.

RESULTS

It was hypothesised that fan identification (H_1), perceived relevance of the programme (H_2), altruistic attribution (H_3), egoistic attribution (H_4), and attitude toward CSR of professional sport (H_5) influence the willingness of sport fans to participate in CSR programmes of professional sport. Table 1 presents the results of the regression analysis.

The regression was significant ($R^2 = 0.61$; $F_{(5, 370)} = 119.12$) at $p<0.001$. The results indicate that the model performed well and accounted for 61% of the variance in sport fans’ willingness to participate in CSR programmes. In terms of the performance of each of the independent variables, perceived relevance of the programme made the most significant positive contribution to predicting the level of willingness to participate (Std $\beta = 0.43$, $p<0.001$), followed by fan identification (Std $\beta = 0.38$; $p<0.001$), and attitude toward CSR (Std $\beta = 0.36$; $p<0.001$). In addition, egoistic attribution contributed negatively to the level of willingness to participate (Std β= -0.13; $p<0.001$). However, the effect of altruistic attribution on willingness to participate was not significant. Thus, all of the hypothesised effects of the independent variables, except altruistic attribution of motives of professional sport on willingness to participate in CSR community programmes were supported.

TABLE 1. **WILLINGNESS TO PARTICIPATE: RESULTS OF REGRESSION ANALYSIS** (N=376)

Independent variables	**Std. β**
Fan identification	0.38***
Perceived relevance	0.43***
Altruistic attribution	0.01
Egoistic attribution	-0.13***
Attitude toward CSR	0.36***
R^2	0.61***
F (df)	119.12 (5, 370)

*** $p<0.001$ CSR= Corporate Social Responsibility

In order to explore whether there were gender and religion differences in the willingness of participants to participate in CSR community programmes, perceived relevance of the programme, altruistic attribution, egoistic attribution and attitude toward CSR of professional sport, MANOVAs were conducted. No significant gender differences were found between male and female participants on a linear combination of the given variables.

A significant difference, however, was found between the group of participants with religious belief and those without (Wilk's Λ= 0.913; $F_{(5, 370)}$= 7.04; p=0.00; multivariate $\eta 2$= 0.09). Examination of the coefficients for the linear combinations distinguishing religious and non-religious groups indicated that attitudes toward CSR of professional sport, perceived relevance of the programme, willingness to participate in CSR programme and altruistic attribution of motive, contributed most to distinguish the groups. Follow up univariate ANOVAs indicated that *willingness to participate* in CSR programmes ($F_{(1, 375)}$= 14.51; p=0.00); *perceived relevance* of the programme ($F_{(1, 375)}$= 9.08; p=0.003); *altruistic attribution* of motive ($F_{(1, 375)}$= 7.60; p=0.006); and *attitude* toward CSR of professional sport ($F_{(1, 375)}$= 24.4; p=0.00) were significantly different between religious and non-religious groups. However, no significant difference was found for the 2 groups in egoistic attribution of motive.

DISCUSSION

The aim of this study was to develop and empirically test a model to explain the willingness of sport fans to participate in CSR community programmes of professional sport. Several important findings emerged from this research.

Firstly, using linear regression modelling, it was found the model performed reasonably well. The five independent variables together accounted for 61% of the variance (a large portion of variance explained) in the dependent variable, willingness to participate. This finding has important implications for professional sport or any other organisations that aim to utilise professional sport as a vehicle to address a social cause or issue. It appears that currently professional sport only target their members as the main potential participants of their CSR community programmes. In a sense, they focus on the segment of the community members with a high level of fan identification. The study provided empirical support for such practices and found that fan identification was a strong indicator of the intention of sport fans to attend the CSR community programme. The result was consistent with the findings of previous studies that found that fan identification was a strong indicator of fans' behavioural intentions, such as game attendance intentions and purchasing intentions of the products of sponsors (Zhang *et al*., 2005; Park & Dittmore, 2014).

In addition to fan identification, perceived relevance of the programme was another strong indicator of the willingness of sport fans to participate in CSR programmes. It contributed even more than fan identification in the current study. This finding corroborates previous findings that consumers respond more positively when the cause was considered to be more important to them (Lafferty, 2007), and that consumers with a level of cause involvement were significantly likely to participate in CSR campaigns, as opposed to those with lower level of cause involvement (Grau & Folse, 2007). The importance of perceived relevance suggests that professional sport should choose carefully what social cause or issue to address in their design of their CSR community programmes. In order to maximise the social benefits through increasing participation, they should choose the ones that are most relevant to the members of their targeted community.

Secondly, the effect of altruistic attribution was found not to be significant on willingness to participate. This was an unexpected result. Ellen *et al*. (2006) found in general business settings that altruistic attribution was positively related to purchase intention. A possible explanation is that all CSR community programmes are promoted to be altruistic by professional sport. Being altruistic is just the way they should be, but not enough to trigger any participation intention among sport fans. As the current study has shown, it is rather the levels of desire of sport fans to be involved with the sport club (fan identification), the levels of relevance they perceive of the social cause the programme supports and the attitude of sport fans toward CSR of professional sport that determines willingness to participate.

It is interesting that while the hypothesis that altruistic attribution had an effect on willingness to participate in CSR programmes was rejected, it supported the hypothesis that egoistic attribution had a significant and negative effect. The implication of the finding for professional sport is that they should be very careful with their promotions of their CSR community programmes. Any scepticism about their motive for offering CSR programmes to be egoistic may significantly reduce the number of people willing to participate in their programmes, and consequently, reduce the social benefits.

Thirdly, significant differences between religious and non-religious groups in willingness to participate in CSR programmes, perceived relevance of the programme, altruistic attribution of motive, and attitude toward CSR of professional sport, were found. Previous studies

examining the link between religion and CSR suggest that the interface between religion and CSR appear to be fragmented and inconclusive (Ramasamy *et al*., 2010; Jamali & Sdiani, 2013). In the current study, participants with religious beliefs had higher scores on all of the variables mentioned. This finding is supported by Ramasamy *et al*. (2010) who found religious belief to be a significant determinant of CSR support. Therefore, it may be inferred that professional sport could attract more participants if they promote their CSR programmes targeting religious groups.

LIMITATIONS AND IMPLICATIONS FOR FURTHER STUDY

There are a few methodological issues related to the present study that warrant consideration.

Firstly, the study used convenience sampling. Although convenience sampling does not ensure that the sample drawn represents the characteristics of the population, it is a sampling technique often utilised for theory testing (Calder *et al*., 1981). The authors were aware that the sample used was a convenience sample, and of the limitations of convenience sampling to the generalizability of the findings. Future studies should randomly draw samples from the general fan population to test the model and variables included in the present study to improve generalizability.

Secondly, even though the relationships were explored, the causal relationships among the dependent variables and independent variables could not be explored. It is recommended, therefore, that further studies examine the causal relationships through either experimental designs or structural models. While the difficulties of experimental designs in sport settings is acknowledged, this type of research design is more effective in examining causal relationships.

Thirdly, behavioural intention (for example, willingness to participate) was used as the dependent variable in this study. It is acknowledged that behavioural intention does not necessarily result in actual overt behaviour (such as participating). While behavioural intention was perceived to be a good predictor of behaviour, future studies might incorporate both behavioural intention and overt behaviour as the dependent variables of the study.

CONCLUSION AND RECOMMENDATIONS

This study has some important contributions to make to both CSR research and practice. Firstly, the research contributes to the CSR literature by shedding light on how social demographic, attitudinal and cognitive factors influence the willingness of sport fans to participate in CSR community programmes. Secondly, this project expands understanding CSR from a social benefit perspective, different from the economic and commercial benefits perspective, which has dominated the literature, thus contributing to the existing literature on CSR by enabling observation of CSR from a holistic perspective. Thirdly, the findings of the research provide a solid foundation for an array of important future research enquiries. Moreover, the measurements created for and tested in this study will aid future CSR research endeavours.

The findings could assist professional sport (and for that matter, any organisations engaging in community CSR practice), to design and deliver their CSR programmes more efficiently and effectively to maximise participation. As a result, more social benefits will be achieved.

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