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JOB SATISFACTION OF SPORT AND PHYSICAL ACTIVITY INSTRUCTORS IN SPAIN ACCORDING TO GENDER AND AGE

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ABSTRACT

The purpose of this study was to assess the extent to which sport and physical activity instructors are satisfied with their working conditions and performance, and how levels of job satisfaction varied across different genders and ages of sport and physical activity instructors. Sport and physical activity instructors (N=600) (ultimately N=545; males=356, females=189), from Spain formed the target group for the survey. Key results indicate that sport and physical activity instructors experienced job satisfaction due to their relationship with their colleagues, the feeling that their occupation was valued by their peers, the job itself, the level of autonomy and the level of their performance. However, they experienced dissatisfaction with the lack of training and promotional opportunities, the financial remuneration, the environmental conditions and lack of personal safety. A major finding was that sport and physical activity instructors who experienced higher levels of job satisfaction were males aged 45 years or older. Despite the fact that the results revealed that sport and physical activity instructors were generally satisfied with their jobs, further research needs to examine ways to increase job satisfaction by reducing negative elements.

Key words: Job satisfaction; Physical activity; Sport instructor; Gender; Age.

INTRODUCTION

Each year, a considerable number of sport and physical activity instructors leave the teaching scene (Raedeke *et al.*, 2002). This could be because they become dissatisfied with their jobs and feel stressed or burnt out and opt to leave (Singh & Surujlal, 2006). Continuous employment of sport and physical activity instructors is important.

The influence that a sport and physical activity instructor has, is crucial not only in terms of the quality of a child's first sport experience, but because they help to lay the foundation of the child's development as future sportsmen or -women and as a person. They inspire them to continue participating in physical activities (Sallis *et al*., 2000). The availability of sport and physical activity instructors is essential for elderly participants as well (Campos-Izquierdo *et al.*, 2010). Sport organisations recognise that the continuous employment of instructors is important in order to maintain quality sport programmes (Raedeke *et al.*, 2002).

In Spain, instructing sport and physical activities is considered an occupation and a function of sport and physical activity (Campos-Izquierdo, 2010). It differs from teaching physical

education because it happens outside the education system and they can instruct people of all ages. It also differs from coaching, because they do not compete. Sport and physical activity instructors can teach all the sport and physical activities in an academic setting, which differs from extracurricular activities because the classes can be performed by all types of people and in any facility, not only in a school.

Campos-Izquierdo *et al*. (2006) and Martínez *et al*. (2008) wanted to know how many people work in every occupation and function of sport and physical activity. The results of their studies revealed that 20 and 18.5% of all people in Spain work as sport and physical activity instructors respectively. As such, it could be concluded that sport and physical activity instruction can be regarded as one of the occupations most practised in Spain.

In the light of sport and physical activity instructors being a highly sought after occupation, research related to job satisfaction of employees as a means to achieve better results in society, needs further investigation. If sport and physical activity instructors are satisfied with their jobs, they produce better and active sportsmen and -women and contribute more to the success of the organisation (Raedeke *et al*., 2002). They also increase the productivity of athletes and influence their commitment (Moodley & Coopoo, 2006).

Over and above the preceding advantages of job satisfaction, overall job performance is also affected (Dixon & Warner, 2010). Campos-Izquierdo (2010) contends that the job satisfaction of the human resources in the field of sport and physical activity is a fundamental factor in their job performance and service quality. In brief, better job performance and service quality could thus ensure the educational, social and health benefits for the society.

Many factors contribute to job satisfaction. Oshagbemi (1997) claim that personal achievement, supervisors, responsibilities, the job itself, compensation, personal safety and working conditions are some of these factors. On the other hand, Koehler (1998) found that sport employees experience job satisfaction with respect to their employment, social services, moral values and personal achievement, but they were not as satisfied with their supervisors, opportunities for promotion and sufficient compensation.

Howell and Higgins (2005) explain that male administrators employed in American and Canadian recreation programmes report higher job satisfaction than females. To the same degree, Moodley and Coopoo (2006) conclude that male personal trainers were more satisfied with their jobs than female personal trainers were. A study by Barrett *et al.* (2002), on the job satisfaction of sport employees, found that older employees were the most satisfied.

OBJECTIVES

Job satisfaction has been investigated in many working environments; however, there is an absence of studies regarding sport and physical activity instructors. Therefore, this

investigation covers some more ground regarding this issue. The specific objectives of this study were:

1. To determine the extent to which sport and physical activity instructors are satisfied with their working conditions and performance.

2. To analyse and compare the job satisfaction of sport and physical activity instructors in terms of gender and age.

METHODOLOGY

A quantitative survey design was employed. The methodology followed in this investigation has been descriptive (Thomas *et al*., 2011). In developing this methodology, the procedures followed were those of a sectional survey (García-Ferrando, 2002), applied to a sample of people who worked in developing job functions of sport and physical activity in Spain (Campos-Izquierdo, 2010).

Respondents

The respondents in this investigation were sport and physical activity instructors (N=600) from Spain who worked in different types of facilities (gymnasia, swimming pools, sport centres) and different types of organisations (publics, sports association, companies). Of the 600 sport and physical activity instructors, 545 were selected because they were employed by someone else; while 55 were rejected as they were self-employed. The participants' were part of a larger project conducted on 2500 people who work in all functions and occupations of sport and physical activity in Spain (Campos-Izquierdo, 2013).

For this study, only sport and physical activity instructors were selected. Of the 545 sport and physical activity instructors that responded 65.3% were male, 34.7% female and their age ranged from 16 to 70 years. As it was an infinite or very large population, a confidence interval of 95.5% was used for this study, which is most accepted for the social sciences (Cea D'Ancona, 1998). Assuming the population variance in the worst case of p equal to 50%, then q=50%, the margin of error sampling allowed is +2% (Cea D'Ancona, 2010).

Instrument

To capture the necessary information for the purpose of the study, a standardised questionnaire "PROAFIDE: Human Resources of sport and physical activity" was used, which has been validated and has analysed the situation and performance of people working in the different fields of sport and physical activity (Campos-Izquierdo, 2011).

From this questionnaire, items related to the objectives of this study were selected. The items were scored on a 5-point Likert-type scale ranging from 1 (very dissatisfied) to 5 (very satisfied) (Thomas *et al.*, 2011). The 5-point scale was selected to avoid having difficulty finding nuance differences between some answers and others (Cea D'Ancona, 2010). On the question regarding the degree of satisfaction, the reliability index obtained through the calculation of the Cronbach's alpha coefficient (alpha=0.900) showed an excellent internal consistency (Nunnally, 1978). In the pre-test, the instrument was administered to 50 sport and physical activity instructors (Cea D'Ancona, 1998; García-Ferrando, 2002; Thomas *et al.*, 2011). Everyone understood the questions and could easily

provide answers.

Analysis of data

A univariate and bivariate descriptive analysis was performed and an inferential analysis by contingency tables including Pearson χ^2 value and significance and the Phi correlation coefficient. Data analysis was performed after being tabulated and mechanised as computerised data by using the statistical package SPSS for WINDOWS (19.0 V) (Pardo & Ruiz, 2005).

Procedure

The survey was conducted personally using the questionnaire on all the people selected from a statistically representative sample of various sport facilities (Bryman, 2004). The people selected worked in various fields of sport and physical activity in all provinces and autonomous regions of Spain.

Ethical clearance

Ethical clearance was obtained from the concerned authorities. The commission validated the objective of this project and the methodology. The Law for the Protection of Data was satisfied and fulfilled, not only during the planning, but also during the project.

RESULTS

The respondents (N=545) in this study were sport and physical activity instructors from Spain. The mean, standard deviation and frequency for the 15 facets of job satisfaction are provided in Table 1.

Most of the sport and physical activity instructors expressed moderate to high levels of job satisfaction. The greatest job satisfaction that they experienced - the mean exceeding 4 on a 5-point scale - were with regard to their relationship with colleagues (item 44.12, $\overline{x}$ =4.5) and to the feeling that their occupation was valued by their peers (item 44.14; $\overline{x}$ =4.4). Sport and physical activity instructors also expressed high levels of job satisfaction with regard to the feeling that their occupation was valued by their customers (item 44.15, $\overline{x}$=4.4) and the job itself (item 44.4; $\overline{x}$ =4.4). Sport and physical activity instructors were also satisfied with the amount of autonomy (item 44. 6, $\overline{x}$=4.3) and the performance expected to be achieved (item 44.5; $\overline{x}$ =4.2).

Finally, the feeling that their occupation was valued by the organisation (item 44.13, $\overline{x}$=4.1) was another item that contributed to the job satisfaction experienced by sport and physical activity instructors. The lowest levels of job satisfaction were experienced with regard to training opportunities offered by the organisation (item 44.11, $\overline{x}$=3.0). Sport and physical activity instructors also expressed low levels of job satisfaction with regard to promotional opportunities within their organisation (item 44.2, $\overline{x}$ =3.1). Low levels of job

satisfaction were also related to the financial remuneration that sport and physical activity instructors

received (item 44.10, $\bar{x}$ =3.2). Finally, general environmental conditions and personal safety (item 44.9, $\bar{x}$ =3.7) were associated with low job satisfaction.

TABLE 1. **ITEM MEANS, STANDARD DEVIATIONS AND FREQUENCIES: JOB SATISFACTION**

Item	Item description	Mean	SD	1	2	3	4	5
44.1	Work organisation in your field	3.7	1.1	4.5	8.3	24.8	35.8	26.6
44.2	Promotional opportunities	3.1	1.2	13.4	13.2	39.8	19.8	13.8
44.3	Assessment and support of your superiors of work done	3.8	1.2	6.2	5.7	25.0	28.8	34.3
44.4	The job itself	4.3	0.9	1.3	2.9	11.2	27.9	56.7
44.5	Performance to be achieved	4.2	0.9	2.0	2.0	17.6	34.9	43.5
44.6	Level of autonomy	4.3	0.9	1.2	2.8	12.7	28.6	54.7
44.7	Working hours, holidays and personal days	4.0	1.1	3.3	7.2	22.0	26.2	41.3
44.8	Job security	3.7	1.3	7.9	8.8	20.9	26.6	35.8
44.9	General environmental conditions and personal safety	3.7	1.2	7.3	9.2	14.6	28.4	30.5
44.10	Perception of financial remuneration	3.2	1.2	10.3	15.2	34.1	25.0	15.4
44.11	Training opportunities offered by the organisation	3.0	1.4	20.7	12.8	31.6	17.8	17.1
44.12	Relationships with colleagues	4.5	0.8	1.7	1.3	8.3	22.0	66.8
44.13	Feeling that their occupation is valued by the organisation	4.1	1.1	4.6	4.6	16.1	31.0	43.7
44.14	Feeling that their occupation is valued by their peers	4.4	0.9	1.8	1.8	11.9	27.3	57.1
44.15	Feeling that their occupation is valued by their customers	4.4	0.9	1.3	2.0	11.9	29.4	55.4

N=545 Frequencies as percentages

Job satisfaction and gender

The respondents included 356 males and 189 females. As seen in Table 2, the females experienced lower levels of job satisfaction than the males. There was not a big difference between genders, but the fact was that females were less satisfied than the males on

every

item. This could be because they felt less valued or because their salaries were generally lower.

TABLE 2. **ITEM MEANS FOR JOB SATISFACTION: GENDER**

	Item description	Mean	
		Male (n=356)	**Female** (n=189)
44.1	Work organisation in your field (philosophy and organisational culture)	3.8	3.5
44.2	Promotional opportunities within your organisation	3.2	2.9
44.3	Assessment and support of your superiors of work done	3.9	3.7
44.4	The job itself	4.4	4.2
44.5	Performance to be achieved	4.2	4.1
44.6	Level of autonomy	4.4	4.2
44.7	Working hours, holidays and personal days	4.1	3.8
44.8	Job security	3.8	3.6
44.9	General environmental conditions (lighting, ventilation, temperature) and personal safety	3.7	3.5
44.10	Perception of financial remuneration	3.3	3.1
44.11	Training opportunities offered by the organisation	3.0	3.0
44.12	Relationships with colleagues	4.6	4.4
44.13	Feeling that their occupation is valued by the organisation	4.1	3.9
44.14	Feeling that their occupation is valued by their peers	4.4	4.3
44.15	Feeling that their occupation is valued by their customers	4.4	4.2
	Overall	4.0	3.8

Job satisfaction and age

The age of respondents ranged from 16 to 70 years. The ages represented were 334 from 16 to 29 years, 169 from 30 to 44 years, 39 from 45 to 59 years and 3 from 60 to 70 years. According to the results depicted in Table 3, as sport and physical activity instructors get older they experience higher levels of job satisfaction. The most satisfied with their jobs were those who were 60 to 70 years old. A possible reason is that as they get older, the daily tasks of the job become more familiar and routine, making the job easier and creating a better sense of job satisfaction.

There were 2 items in Table 3 that were interrelated but did not follow the rule as shown before, namely assessment and support of superiors in the workplace (item 44.3, $\overline{x}$ =3.7) and the feeling that their occupation was valued by the organisation (item 44.13, $\overline{x}$=3.9). Sport and physical activity instructors aged 45 to 59 years were less satisfied regarding these items than those aged 16 to 45 years. This may be because organisations support new workers, who are usually young, more.

TABLE 3. **ITEM MEANS FOR JOB SATISFACTION: AGE**

	Item description	Mean (years) 16-29 (n=334)	30-44 (n=169)	45-59 (n=39)	60-70 (n=3)
44.1	Work organisation in your field	3.7	3.7	4.2	5.0
44.2	Promotional opportunities within your organisation	3.0	2.4	3.1	4.7
44.3	Assessment and support of your superiors of work done	3.8	3.7	3.7	5.0
44.4	The job itself	4.3	4.3	4.5	5.0
44.5	Performance to be achieved	4.1	4.2	4.3	5.0
44.6	Level of autonomy	4.2	4.3	4.6	5.0
44.7	Working hours, holidays and personal days	3.8	4.1	4.2	5.0
44.8	Job security	3.5	3.9	4.4	4.7
44.9	General environmental conditions and personal safety	3.6	3.6	3.6	3.7
44.10	Perception of financial remuneration	3.1	3.2	3.3	4.7
44.11	Training opportunities offered by the organisation	3.0	2.8	3.2	3.7
44.12	Relationship with colleagues	4.1	4.5	4.4	5.0
44.13	Feeling that their occupation is valued by the organisation	4.0	4.0	3.9	5.0
44.14	Feeling that their occupation is valued by their peers	4.3	4.4	4.4	5.0
44.15	Feeling that their occupation is valued by their customers	4.3	4.4	4.5	5.0
	Overall	3.8	3.8	4.0	4.8

DISCUSSION

Most sport and physical activity instructors expressed moderate to high levels of job satisfaction. This is the key finding that was noted in related studies questioning job satisfaction in the field of sport (Chelladurai & Ogasawara, 2003; Surujlal, 2004). Overall, the relationship with colleagues and the feeling that their peers' value their occupation seemed to be the most satisfactory work factors influencing job satisfaction. Oshagbemi (1997) investigated along the same line with respect to educators and he showed that their co- workers' behaviours, congeniality with colleagues, friendship with colleagues and collaboration with colleagues play an important role in their job satisfaction. Based on the results (Table 1) obtained in this study, it can be said that it is critical for sport and physical activity instructors to have good interpersonal relationships as this could reduce internal conflict and improve job satisfaction (Singh & Surujlal, 2006). This assumes that camaraderie and sense of community may be a distinguishing factor between those who perceive

themselves as having a "good" job and those who identify themselves as having a "great" job (Dixon & Warner, 2010).

Sport and physical activity instructors also expressed high levels of job satisfaction with regard to the feeling that their customers valued their occupation and that the job itself was valued. Koustelios (2001) also found that teachers expressed job satisfaction and according to Chelladurai and Ogasawara (2003) coaches reported that the highest levels of job satisfaction lay within intrinsic elements, such as the occupation itself and their autonomy.

With regard to the factors referred to by Chelladurai and Ogasawara (2003), sport and physical activity instructors in this study were satisfied with the amount of autonomy and the performance expected to be achieved. Li (1985) stated that the sense of responsibility that teachers perceive from their job is important to their job satisfaction.

Another item from which sport and physical activity instructors felt job satisfaction was the feeling that their occupation was valued by the organisation. It is important to have the support of managers. These results imply that sport and physical activity instructors experience the most job satisfaction from situations that they have control over (Singh & Surujlal, 2006), as well as from intrinsic factors, according to Raedeke *et al*. (2002) and Chelladurai and Ogasawara (2003).

When examining job dissatisfaction among the sport and physical activity instructors, the lowest levels of job satisfaction were experienced with regard to training opportunities offered by the organisation. This was a factor of concern in the research conducted by Moodley and Coopoo (2006), in which the personal trainers and self-employed trainers expressed the reality that they did not have the opportunity to enhance their existing skills. By providing workers with ways to improve their abilities, it would enhance their sense of self- pride, competence and self-confidence (Gerber *et al.*, 1998).

Sport and physical activity instructors also expressed low levels of job satisfaction with regard to promotional opportunities within their organisation. Likewise, Koustelios (2001) found this item as dissatisfactory among teachers. A lack of promotional opportunities leads to negative feelings and overall dissatisfaction. These negative feelings arise when employees are not promoted when they consider themselves worthy of a promotion (Smucker & Kent, 2004).

In this study, low levels of job satisfaction were also related to financial remuneration. Salary is a key determinant of job satisfaction. Many studies found it to be a factor that decreases job satisfaction of employees (Koustelios, 2001; Surujlal, 2004; Moodley & Coopoo, 2006). Supporting this point, Barrett *et al*. (2002) found that athletic trainers who earn $50,000 or more are almost 15% more satisfied than those who earn $49,999 or less. Smucker and Kent (2004), indicate that low levels of job satisfaction go along with low pay, lack of promotion and negative working conditions and support the findings about job dissatisfaction among the sport and physical activity instructors. These findings are similar to those reported by Chelladurai and Ogasawara (2003), Howell and Higgins (2005), Singh and Surujlal (2006) and Sánchez-Alcaraz and Parra-Meroño (2012).

Despite the fact that there was not a significant difference between the genders in this investigation, females experienced lower levels of job satisfaction than the males. This

could be ascribed to the females feeling less valued or because their salaries are generally lower than that of the males. Similar to these results, Howell and Higgins (2005) in their study of sport administrators employed in American and Canadian recreation programmes found that males showed higher levels of job satisfaction than females. These results are consistent with the study of Moodley and Coopoo (2006), where the female personal trainers were less satisfied than their male counterparts.

Another interesting finding of this study relates to age. The sport and physical activity instructors in the age range 60 to 70 years were most satisfied with their jobs. Bell (1989) and Barrett *et al.* (2002) support this finding. They posit that age has an impact on job satisfaction, noting that as age increases, so does job satisfaction. Skaalvik and Skaalvik (2011) affirmed that older teachers were more satisfied with their work situation. A reason for this result could be that at some later stage, the daily tasks of the job become more familiar and routine, making the job easier and creating a better sense of job satisfaction. In addition, as you get older you have more experience, so you are more likely to be promoted and your salary and job responsibilities are likely to increase (Barrett *et al*., 2002). Surprisingly, the sport and physical activity instructors in the age range of 45 to 59 years were less satisfied with these two items, also the feeling that their occupation was valued by their organisation and the support and assessment of their superiors regarding the work done, than the sport and physical activity instructors aged 16 to 44 years. This could be because their superiors need to support younger employees in order to teach them the entity, philosophy and way of working and spend less time in assessing or supporting older employees (aged 45 to 59 years), who have more experience and are accustomed to working in the same organisation.

PRACTICAL APPLICATION

Job satisfaction is important as it affects sport and physical activity instructors, sportsmen and -women, the organisations and society (Campos-Izquierdo, 2010). It is necessary to know the extent of job satisfaction of the sport and physical activity instructors, because in Spain it is the occupation of the majority of working people. This research could provide directives for improving the sport management profession.

CONCLUSION

In conclusion, this study suggests that sport and physical activity instructors experience job satisfaction because of the relationships with their colleagues, the feeling that their occupation is valued by their peers, the job itself, the level of autonomy and their performance to be achieved. However, they derive dissatisfaction from the lack of continued training and promotional opportunities, unsatisfactory financial remuneration, the inadequate environmental conditions and lack of personal safety. Therefore, these aspects should be taken into account when improving the working situation of the sport and physical activity instructors. The existence of this occupation is important, as it improves the quality and efficiency of services. If sport and physical activity instructors are dissatisfied, they are less productive and could possibly leave this field of work. Although there is not a big difference, male sport and physical activity instructors experience higher levels of job satisfaction than

females. According to age, sport and physical activity instructors that are more senior, feel

greater levels of job satisfaction. Despite the fact that the results reveal that sport and physical activity instructors are generally satisfied with their jobs, further research needs to look for ways to increase job satisfaction by reducing dissatisfying elements.

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STRENGTH, RUNNING SPEED, AGILITY AND BALANCE PROFILES OF 9- TO 10-YEAR-OLD LEARNERS: NW-CHILD STUDY

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ABSTRACT

The purpose of this study was to determine the strength, running speed and agility, and balance profiles of 9- to 10-year old learners and the relation between these skills of the learners. Using a stratified random selection from 20 schools with different socio-economic backgrounds, 862 9- to 10-year-old learners (457 boys; 405 girls) were tested in four educational districts. The Bruininks-Oseretsky test of Motor-Proficiency, second edition, was used to evaluate the learners. The results showed statistical ($p \leq 0.05$) and practical ($d \geq 0.5$) significant gender differences with regard to strength, running speed and agility and balance skills. The boys preformed significantly better than the girls did in the standing long jump, push-ups, sit-ups, V-sit, shuttle run, walking heel-to-toe forward on a line, while the girls outperformed the boys in the stepping sideways over a balance beam and walking heel-to-toe forward on a line. The majority of the total group were categorised as average for strength (76.59%), agility (63.38%) and balance skills (55.85%), while 34.88% of the group showed below-average balance skills. Significant correlations ($r \approx 0.1$) were found among the different skills.

Key words: Strength; Running speed and agility; Balance; Motor performance; Children.

INTRODUCTION

Satisfactory motor development plays an important role in a child's life and enables the child to participate in kinetic activities that contribute to physical and cognitive growth (Barton *et al.*, 1999; Goudas & Giannoudis, 2008). Strength, agility and balance are important components of motor development and are regarded as prerequisites for effective movement (Pienaar, 2012). Several research studies have found that children nowadays show an insufficient level of physical fitness skills when considering components such as aerobic fitness, strength, agility, perseverance and balance (Volbekiene & Griciute, 2007; Keller, 2008; Mak *et al*., 2010; Fjørtoft *et al*., 2011; Pienaar *et al*., 2012; Ross *et al*., 2014). Children with inadequate motor skills also display low levels of physical fitness skills (Okely *et al*., 2001; Cairney *et al.*, 2006; Haga, 2008; Hands, 2008; Fjørtoft *et al*., 2011).

Muscle strength is a primary component of physical fitness skills and increases commensurate with age from the early childhood years up to adolescence (Winnick, 2005). This linear relationship continues to about the age of 15 years in girls, while a marked increase can be observed in the strength of boys during puberty, which continues at a slower rate during the late teens (Pienaar, 2012). The research of Wang and Chen (1999), on 9- to

12-year-old Taiwanese children, found gender differences in muscle strength, as the boys performed better compared to the girls. Pienaar (2012) supports this finding by pointing out that gender differences with regard to strength can be better observed in the upper limbs and core, where boys showed significantly greater strength than girls did.

Although boys seem to be stronger than girls are, muscle and strength development occurs at the same rate in both genders up to about age 11 (Gallahue & Ozmun, 2006). There is controversy in literature with regard to gender differences. The results of a study by Lazzer *et al*. (2009) on 8- to 12-year-old Italian children contradict the above as they found that boys had a higher count for absolute peak strength compared to girls. A study by Holm *et al*. (2008) found no meaningful gender differences in the strength skills of 7- to 12-year-old children in Norway. Chad *et al*. (1999) and Kraemer and Fleck (2004), in turn are of the opinion that strength skills are important to improve the general fitness and health of sportspeople and to prevent injury. Additionally, it seems that if children's strength skills are inadequately developed, their freedom of movement is limited, which may possibly influence motor skills negatively (Payne & Isaacs, 2008).

According to Annesi *et al*. (2005) *agility* is the ability to change body position quickly and accurately with ease and flow, while maintaining control and balance. Agility can further be seen as a combination of speed, balance, strength and coordination (Sherrill, 2004). Agility skills are responsible for the combination of reaction time, acceleration and explosiveness (Ball *et al*., 1992; Lori *et al*., 1998; Baker & Newton, 2008), which are central to sport performance (Bullock *et al*., 2012). When it comes to gender differences, Saygin *et al*. (2007) could not find any with regard to agility in their study on 853 (436 boys, 417 girls) children between 9 and 13 years of age in Turkey.

There is, however, controversy in the literature on the matter of gender differences related to agility as well, because some researchers did find differences (Malina *et al*., 2004; Gallahue & Ozmun, 2006). In this regard, Gallahue and Ozmun (2006) revealed that the running speed and agility of boys and girls are similar up to the age of 7 years, after which the boys improve their performance significantly between the ages of 8 and 12 years. The research of Moneyki *et al*. (2003) on disadvantaged South African children found significant gender differences related to strength, agility and balance. Malina *et al*. (2004) also highlight the fact that boys do better in activities that require speed and strength, while girls do better in activities that require balance and fine motor skills. Yet, several research studies point out that 12- to 18- year-old children these days show insufficient strength and agility skills for their age (Volbekiene & Griciute, 2007; Mak *et al*., 2010).

Stability skills form part of a fundamental group of skills that can be divided into two types, namely *stationary balance* (the ability to maintain a stable support base with minimal disturbance of the movement), and *dynamic balance* (the ability to maintain a stable bodily position while moving) (Winter *et al*., 1990; Pienaar, 2012). Several researchers (Al-Haroun, 1988; Malina *et al.*, 2004; Lam, 2008), indicate that girls do markedly better than boys in activities that require balance. According to Gallahue and Ozmun (2006), there is a commensurate improvement in balance among all children between the ages of 2 and 12 years. In addition, these researchers show that girls have better balance skills than boys up to the age of 8 or 9 years approximately, after which boys start to catch up. Although literature

seems to posit that balance skills improve with age, the study in Kaohsing City on 99 (58 boys and 41 girls), children between 9 and 12 years found no meaningful improvement (Wang & Chen, 1999). The findings of these researchers indicate that age and gender are not necessarily decisive factors when considering the balance skills of boys and girls (Wang & Chen, 1999). However, the inability to balance may lead to scholastic problems, because adequate balance enables a child to sit still (Cheatum & Hammond, 2000).

The literature is also inconsistent regarding the relationships between strength, agility and balance. A study by Kin-İşler *et al*. (2008) on 25-year-old professional American basketball players did not find any relationship between strength, agility and balance, whereas Katic *et al*. (2012) offer findings of research conducted in Croatia with 10- to 14-year-old learners that show a positive relationship between intelligence, the speed of simple movements, balance, agility and strength. The literature does show that there is a direct link between sufficient strength and agility skills and sport achievement (Ball *et al*., 1992; Baker & Newton, 2008). Wang and Chen (1999) measured the relationship between balance and muscular strength in children aged 9 to 10 years and found that there was a positive relationship between dynamic strength and balance, as well as between dynamic and static strength, while a strong negative relationship was found between static strength and balance. According to research by Muelhbauer *et al*. (2013) on 7- to 10-year-old children in Germany, no meaningful relationships between strength, balance and mobility were found.

After an examination of the literature available on strength, running speed and agility and balance skills, it seems that there is a lack of research for these skill profiles of 9- to 10-year- old boys and girls in the North-West Province of South Africa. Moreover, there seems to be a shortcoming in the availability of literature that addresses the relationship between strength, agility and balance in 9- to 10-year-old learners.

PURPOSE OF RESEARCH

The research questions are firstly: What are the current strength, running speed and agility, and balance profiles of 9- to 10-year-old boys and girls from the North-West Province? Secondly, what is the relationship between strength, running speed and agility and the balance skills of 9- to 10-year-old learners from the North-West Province? The answers will establish a profile of these skills for this age group that would be useful for Kinderkineticists and teachers working on these skills of boys and girls. Furthermore, it should provide Kinderkineticists and sport coaches with guidelines on the influence that strength, running speed and agility, and balance skills have on one another and their effect on the improvement of the sport performance of these learners.

METHODOLOGY

Research design

The study was based on a longitudinal research design (NW-CHILD study), stretching over a period of 6 years (2010-2016) and that comprised baseline measurements and 2 follow-up measurements. The baseline data was collected in 2010. The first follow-up measurements were conducted in 2013 on a selected group of learners residing in the different areas of the

North-West Province of South Africa. Only data from the first follow-up measurements (2013), have been utilised for the purpose of this study.

Research group

The research forms part of the NW-CHILD study (Child-Health-Integrated-Learning and Development). The aggregate number of Grade 1 learners in the North-West Province of South Africa that participated in the study as the target population, included 816 learners. The sample was selected by means of a randomised selection from a stratified 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 this Province are grouped into 4 education districts. Each of these districts consists of 12 to 22 regions and each region has approximately 20 schools (minimum 12, maximum 47). Regions and schools were randomly selected from this list with regard to population density and school status (Quintile 1 schools from poor economical areas, to Quintile 5 schools from affluent economical areas). Boys and girls in Grade 1 were selected randomly from each school. 20 schools with a minimum of 40 children per school and with an equal division of genders were involved in the study. The follow-up target population for the study in 2013 included learners, who were mainly in Grade 4, yet there were some of the learners who were still in Grade 3. The descriptive data of all the learners that participated in this study are presented in Table 1.

Measuring instruments

The Bruininks-Oseretsky Test of Motor Proficiency-2 (BOT-2)

The 'Bruininks-Oseretsky Test of Motor-Proficiency', second edition (BOT-2) (Bruininks & Bruininks, 2005), was used to evaluate the children's strength, running speed and agility, and balance skills. This test battery is a standardised, norm-based and individual application measurement 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 and the running speed and agility sub-items consist of 5 activities each. The *strength* component includes the following items: standing long jump (cm), push-ups (number performed correctly in a given time), sitting against a wall (seconds the position could be held), sit-ups (number performed correctly in a given time) and the V-sit (seconds the position could be held). The *running speed and agility* component includes the following items: the 15m shuttle run (seconds), side-hop over a balance beam (number performed correctly in a given time), 1-legged standing jumps (number performed correctly in a given time), 1-legged side-hop (number performed correctly in a given time), as well as 2-legged side-hops (number performed correctly in a given time). The *balance* component comprises 9 sub-tests, which include the following: standing on a line with open eyes (seconds), walking forward on a line (number of steps placed on the line correctly), standing on 1 leg on a line with open eyes (seconds), standing on a line with closed eyes (seconds), walking heel-to-toe on a line (number of steps placed on the line correctly), standing on 1 leg on a line with closed eyes (seconds), standing on 1 leg on a balance beam (seconds), standing heel-to-toe on

a balance beam (seconds) and lastly standing on a balance beam on 1 leg with closed eyes (seconds).

During the execution of a test component, the child was allowed 2 attempts of which the best raw score was used for 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 and 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).

Procedure

The North-West University Ethics Committee (No. 00070-90-A1) granted ethical approval for the research. Approval was also received from the Department of Basic Education of the North-West Province to perform the research in the schools. The school principals of the identified schools approved collecting the data during school hours. Informed consent forms were sent to the parents of all the learners who participated in the study in 2010 to ensure that a minimum of 40 learners between the ages of 9 and 10 years participated. If some learners moved away or parents did not return the forms, new learners were randomly selected at that school to make up the 40 learners required.

If the learners were not proficient in English as a home language or first additional language, local interpreters that were trained before the commencement of the study, were used to communicate the necessary instructions of the different tests administered to the learners.

Statistical analysis

For data processing, the "STATISTICA for Windows 2012" computer programme was used (StatSoft, 2012). For descriptive purposes, the 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 strength, running speed and agility and balance 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: $d \geq 0.2$ indicated a small effect, $d \geq 0.5$ a medium effect and $d \geq 0.8$ a large effect (Cohen, 1988).

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 at the accepted level of $p \leq 0.05$. The strength of the correlations were 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). Lastly, a Spearman rank order correlation was used to determine the relationships between the strength, running speed and agility and balance skills of the boys, girls and aggregate for

the group respectively. The strength of the correlations is given with r≥0.1 indicating a small effect, r≥0.3 a medium effect and r≥0.5 a large effect.

RESULTS

Table 1 shows the composition of the study population for age by gender. Of the 862 subjects, 457 were boys and 405 were girls. The group had an average age of 9.90 years (SD=0.42), with the boys showing a slightly higher average age than the girls.

TABLE 1. **DESCRIPTIVE PARAMETERS FOR AGE IN RELATION TO GENDER GROUP**

Subjects	N	Min	Max	Mean	SD
Boys	457	8.65	10.84	9.94	0.41
Girls	405	8.20	11.05	9.86	0.42
Total group	862	8.20	11.05	9.90	0.42

Min=Minimum Max=Maximum SD=Standard Deviation

The independent t-test was conducted to determine the significance of gender differences with regard to strength, running speed and agility and balance skills.

Table 2 shows that statistically ($p \leq 0.05$) and practically significant ($d \geq 0.5$) gender differences were noticeable from the tests of strength skills, where the boys did better with the standing long jump, push-ups, sit-ups and V-sit, while the girls only performed better with the wall sit. The girls did better in 4 (side-hop, standing 1-legged jumps, 1-legged side-hop and 2-legged side-hop), of the running speed and agility skills tests than the boys, although statistically ($p \leq 0.05$) and practically ($d \geq 0.5$), meaningful differences were only found for the 15m-shuttle run where the boys performed better than the girls, and the side-hop, where the girls did better than the boys.

Table 2 in the last instance reveals that the boys performed better in 6 (standing on 1 leg - eyes open, standing on a line - eyes open, heel-to-toe walking, standing on 1 leg on a balance beam - eyes open, heel-to-toe standing on a balance beam and standing on 1 leg on a balance beam - eyes closed), of the 9 balance components, although there was only a statistically and practically meaningful significance with the heel-to-toe walking ($p \leq 0.01$ and $d=0.20$). The girls only performed better in 2 (walking forward on a line and standing on a line with closed eyes), balance components than the boys, although there was no statistical or practical significance.

Table 3 shows the strength, running speed and agility, as well as the balance skills of the 9- to 10-year-old learners. The results of the strength skills reveal that there were statistically ($p<0.05$), as well as medium ($d \geq 0.5$) and small ($d \geq 0.2$) practically significant differences between the raw count, the scale score of boys and girls, the aggregate scale score and aggregate age equivalent. There were statistically ($p \leq 0.05$), but not practically significant differences in the age equivalent of the boys and girls. The strength skills of the boys' average

age equivalent are significantly higher than the chronological age of the boys and girls (11.80 compared to 9.94 and 11.28 compared to 9.86).

TABLE 2. **GENDER DIFFERENCES: STRENGTH, RUNNING SPEED, AGILITY AND BALANCE SKILL SCORES FOR EACH SUBTEST**

Variable	**Boys** (n=457) Mean±SD	**Girls** (n=405) Mean±SD	**Significance of differences** df	t	p-Value	d-Value
Strength skills						
Standing long jump	46.58±9.27	42.05±7.83	860	7.69	**<0.001***	**0.49**$^{\#\#}$
Push-ups	20.85±5.45	16.40±5.24	860	12.19	**<0.001***	**0.82**$^{\#\#\#}$
Sit-ups	18.30±6.13	15.81±5.96±	860	6.02	**<0.001***	**0.41**$^{\#}$
Wall sit	55.49±10.78	55.92±9.97	860	0.60	0.551	
V-sit	53.58±12.68	53.09±13.83	860	0.54	0.588	
Running speed & agility skills						
15m-shuttle run	8.48±0.76	9.03±0.92	860	9.59	**<0.001***	**0.60**$^{\#\#}$
Side-hop	34.88±8.08	36.35±7.43	860	2.78	**<0.006***	**0.18**$^{\#}$
Standing one-legged jumps	41.39±8.28	41.82±8.70	860	0.74	0.459	
One-legged side-hops	24.97±6.90	25.19±7.05	860	0.45	0.649	
Two-legged side-hops	28.86±6.11	29.50±6.34	860	1.49	0.137	
Balance skills						
Standing on a line – open eyes	9.98±0.30	9.98±0.30	860	0.24	0.808	
Walking forward on a line	5.93±0.30	5.95±0.28	860	0.69	0.493	
Standing on one leg – open eyes	9.86±0.83	9.85±1.04	860	0.19	0.846	
Stand on a line – closed eyes	9.56±1.47	9.37±1.77	860	1.69	0.091	
Walking heel-to-toe	5.43±1.00	5.17±1.28	860	3.37	**<0.001***	**0.20**$^{\#}$
Standing on one leg – closed eyes	6.97±3.11	7.22±3.39	860	1.15	0.249	
Standing on one leg on balance beam – eyes open	9.32±1.88	9.28±1.95	860	0.34	0.736	
Standing heel-to-toe on balance beam	9.33±1.81	9.32±1.91	860	0.07	0.946	
Standing on one leg on balance beam – eyes closed	4.55±2.81	4.36±2.97	860	0.96	0.338	

SD=Standard Deviation; df=degrees of freedom; t=t-Value; $^{*}p\leq0.05$; $^{\#}$Practical significance small effect $d=\geq0.2$; $^{\#\#}$ Practical significance, medium effect $d=\geq0.5$; $^{\#\#\#}$ Practical significance, large effect $d=\geq0.8$.

TABLE 3. **GENDER DIFFERENCES: STRENGTH, RUNNING SPEED & AGILITY AND BALANCE SKILL FOR COMBINED SUBTEST SCORES**

Variable	**Boys** (n= 457) Mean±SD	**Girls** (n= 405) Mean±SD	**Significance of differences** df	t	p-Value	d-Value
Strength skills						
Raw score	27.77±3.93	25.59±3.51	860	8.55	**<0.001***	**0.55**[##]
Scale score of boys & girls	17.78±3.04	16.54±2.99	860	6.00	**<0.001***	**0.41**[#]
Total scale score	17.75±3.38	15.96±3.01	860	8.20	**<0.001***	**0.53**[##]
Age equivalent of boys & girls (yrs)	11.80±2.09	11.28±2.82	860	3.08	**0.002***	
Combined age equivalent (years)	12.74±3.13	10.80±2.43	860	10.07	**<0.001***	**0.62**[##]
Running speed & agility skills						
Raw score	37.35±3.62	37.18±3.68	860	0.68	0.494	
Scale score of boys & girls	17.47±2.92	18.12±3.19	860	3.10	**0.002***	**0.20**[#]
Total scale score	18.04±3.20	17.94±3.26	860	0.45	0.655	
Age equivalent of boys & girls (yrs)	12.90±3.23	13.82±4.42	860	3.54	**<0.001***	**0.21**[#]
Combined age equivalent (yrs)	13.78±4.07	13.49±4.02	860	1.04	0.299	
Balance skills						
Raw score	31.77±3.16	31.55±3.30	860	1.01	0.311	
Scale score of boys & girls	13.56±4.45	12.30±4.51	860	4.10	**<0.001***	**0.28**[#]
Combined scale score	13.18±4.55	13.04±4.57	860	0.46	0.642	
Age equivalent of boys & girls (yrs)	9.39±4.32	9.02±4.58	860	1.23	0.219	
Combined age equivalent (yrs)	9.02±4.87	8.82±4.64	860	0.61	0.540	

SD=Standard Deviation df=degrees of freedom t=t-Value [*]p≤0.05
[#] Practical significance small effect *d*=≥0.2 [##] Practical significance medium effect d=≥0.5.

For the running speed and agility skills, only statistical (p≤0.05) and small practical (d≥0.2) significance were found with regard to the scale score and age equivalent of the boys and girls. From Table 3, it seems that the age equivalent for the boys and girls were significantly higher than their chronological age (12.9 compared to 9.94 and 13.82 compared to 9.86 respectively). In the case of the balance skills, only a statistical (p≤0.5) and small practical (d≥0.2) significance were found in the scale score of the boys and girls. The age equivalent of the boys and girls was lower than their chronological age (9.39 compared to 9.94 and 9.02 compared to 9.86) (Table 3).

TABLE 4. **STRENGTH, RUNNING SPEED AND AGILITY, AND BALANCE SKILLS ACCORDING TO SKILLS CATEGORY**

Variable	**1** n	%	**2** n	%	**3** n	%	**4** n	%	**5** n	%
Strength skills										
Boys (n=457)	0	0	11	2.41	312	68.27	127	27.79	7	1.53
Girls (n=405)	0	0	15	3.69	349	85.96	41	10.10	1	0.25

Group (N=862)	0	0	26	3.01	661	76.59	168	19.47	8	0.93
Running speed & agility skills										
Boys (n=457)	0	0	1	0.22	294	64.33	157	34.35	5	1.09
Girls (n=405)	0	0	4	0.99	253	62.32	147	36.21	2	0.49
Group (N=862)	0	0	5	0.58	547	63.38	304	35.23	7	0.81
Balance skills										
Boys (n=457)	0	0	152	33.26	257	56.24	48	10.50	0	0
Girls (n=405)	0	0	149	36.70	225	55.42	32	7.88	0	0
Group (N=862)	0	0	301	34.88	482	55.85	80	9.27	0	0

1=Far below average; 2=Below average; 3=Average; 4=Above average; 5=Far above average
Strength skills: w=0.24, p≤0.001; Running speed & agility skills: w=0.06, p=0.322; Balance skills: w=0.05, p=0.309

Two-way frequency tables were used to show the strength, running speed and agility and balance skills according to skill categories. Table 4 shows the tested skills and the different skills categories for the aggregate group, as well as boys and girls separately. For these different skills categories, there were no learners in the far below average category, while for balance no learners were in the far above average skills category. The majority of the learners were in the average skills category for strength (n=661, 76.59%), running speed and agility (n=547, 63.38%) and balance (n=482, 55.85%).

The second largest number of learners were in the above average category for strength (n=168, 19.47%) and running speed and agility (n=304, 35.23%), while 301 (34.88%) learners were in the below average category for balance skills. There was no statistical or practical significant difference between boys and girls in the *running speed and agility skills* (p=0.322 & w=0.06) and *balance skills* (p=0.309 & w=0.05). However, the boys performed statistically (p≤0.001 & w=0.24) and practically better than the girls in the *strength skills*.

Lastly, a Spearman rank order correlation was used to determine the relationships between the strength, running speed and agility and balance skills of the boys, girls and the aggregate group respectively. Relationships with a small to large practical significance can be observed in Table 5 between strength, running speed and agility and balance skills.

TABLE 5. **RELATIONSHIP BETWEEN STRENGTH, RUNNING SPEED AND AGILITY, AND BALANCE SKILLS**

Variables	**Strength** Raw score	**Strength** Scale score	**R-S-A** Raw score	**R-S-A** Scale score	**Balance** Raw score	**Balance** Scale score
***Boys* (n=457)**						
Strength raw score	—	0.94***	0.37**	0.36**	0.09	0.08
Strength scale score	0.94***	—	0.33**	0.38**	0.10*	0.12*
RSA raw score	0.37**	0.33**	—	0.93***	0.23*	0.20*
RSA scale score	0.36**	0.38**	0.93***	—	0.22*	0.23*
Balance	0.09	0.10*	0.23*	0.22*	—	0.99***

raw score						
Balance scale score	0.08	0.12*	0.20*	0.23*	0.99***	—
Girls **(n=405)**						
Strength raw score	—	0.94***	0.29*	0.29*	0.20*	0.20*
Strength scale score	0.94***	—	0.27*	0.33**	0.20*	0.23*
RSA raw score	0.29*	0.27*	—	0.95***	0.20*	0.19*
RSA scale score	0.29*	0.33**	0.95***	—	0.20*	0.21*
Balance raw score	0.20*	0.20*	0.20*	0.20*	—	0.99***
Balance scale score	0.20*	0.23*	0.19*	0.21*	0.99***	—
Group **(N=862)**						
Strength raw score	—	0.95***	0.33**	0.32**	0.14*	0.13*
Strength scale score	0.95***	—	0.30**	0.35**	0.15*	0.17*
RSA raw score	0.33**	0.30**	—	0.94***	0.21*	0.19*
RSA scale score	0.32**	0.35**	0.94***	—	0.21*	0.22*
Balance raw score	0.14*	0.14*	0.21*	0.21*	—	0.99***
Balance scale score	0.13*	0.17*	0.19*	0.22*	0.99***	—

RSA=Running speed & agility; *=r≈0.1 small correlation, **=r≈0.3 medium correlation, ***=r≈0.5 large correlation

For the boys, strength and running speed and agility showed a medium correlation (r≈0.3), while there was only a small correlation (r≈0.1) between running speed and agility and balance. In the case of the girls, there was only a small correlation (r≈0.1) between strength and running speed and agility skills, strength and balance skills, as well as running speed and

agility and balance skills. The whole group showed a medium correlation (r≈0.3) between strength, running speed and agility skills. Lastly, a small correlation was found between strength and balance skills; and running speed, agility and balance skills.

DISCUSSION

This study firstly aimed to determine the strength, balance and running speed and agility profiles of 9- to 10-year-old learners in the North-West Province and secondly, to determine the relationships between strength, balance and running speed and agility for this group.

It seems from the results that the average age equivalent of the boys and girls for strength skills was 11.80 and 11.28 respectively and for running speed and agility it was 12.90 and
13.82 respectively. These were above average, while the average age equivalent for balance was only 9.02 and 8.82 respectively. It can be deduced from this that the strength and

agility skills of the boys and girls were above average, while their balance skills were below average. The possible reason for the high average age equivalent for the strength and agility skills of the 9- to 10-year-old learners is that during the growth and development phase of these children, they tend to be more physically active (Saygin *et al*., 2007).

Another explanation could possibly be that the stature of boys and girls decrease gradually during the prepubertal period and that girls reach their stage of peak height velocity earlier than boys do (Monyeki *et al*., 2005; Marta *et al*., 2012). However, there are contradictions in the literature, where, amongst others, researchers have reported that 12- to 18-year-old children nowadays have insufficient strength, running speed and agility skills for their age (Volbekiene & Griciute, 2007; Mak *et al*., 2010). The results of this study do not support this conclusion, since it found that 9- to 10-year-old learners do have sufficient strength and agility skills for their age.

Furthermore, this study found statistically and practically significant gender differences regarding strength, running speed and agility and balance skills. The study results revealed that boys did better in four (standing long jump, push-ups and sit-ups, V-sit), of the five strength skills when compared to girls. This finding is supported by the research of Wang and Chen (1999), who found that there were gender differences when measuring the muscle strength of 9- to 12-year-old children. Pienaar (2012) also indicated that boys are somewhat stronger in their upper limbs compared to girls, which supports the results found in this study. In this regard, strength skills in boys are promoted as parents place more emphasis on the gross motor skills of boys, which leads to rougher play among boys.

The current findings contradict the findings of Holm *et al*. (2008), who reported no meaningful gender differences in the strength skills of 7- to 12-year-old children, which means that boys and girls will perform the same in the different test components. However, when it comes to sit-ups, the boys performed statistically and practically significantly better than the girls in the current study ($p<0.001$, $d=0.41$). The studies of Monyeki *et al*. (2003) and Milanese *et al*. (2010), reported similar results since the first-mentioned study on 7- to 14- year-old learners, boys jumped further than girls of the same ages, while the last-mentioned research on 6- to 12-year-old learners, showed that boys jumped further when performing the standing long jump. However, these findings are contrary to the study of Marta *et al*. (2012)

where boys did practically, but not statistically, significantly better in the push-ups ($p<0.001$) and sit-ups ($p<0.001$), as well as for the research of Prista (1998), where it was reported that girls did better than boys in sit-ups.

With regard to the running speed and agility skills, this study revealed gender differences as well, since the girls performed better in four (the side-hop, standing one-legged jumps, one-legged side-hops and two-legged side-hops), of the five subtests, while the boys only performed better in the 15m-shuttle run. However, the findings of this study are not reflected in the studies of several researchers. Yanci *et al*. (2012) found that there were meaningful gender differences at the age of 9- to 10-years and that the agility skills of boys and girls improved proportionately to their increase in age, but that boys had significantly greater improvement than girls did. In the study of Lam and Shiller (2001) on 5- to 6-year-old children in Hong Kong, boys performed markedly better in all the components for running speed and agility. Malina *et al*. (2004) and Gallahue and Ozmun (2006) argue that

there are gender differences with running speed and agility because they found that 8- to 12-year-old boys performed better in these skills than the girls.

In contrast to the results from the present study, the study of Saygin *et al*. (2007) on 853 Turkish school children comprising pre-pubertal (212 boys, 199 girls), and pubertal (222 boys, 218 girls), found no gender differences for running speed and agility skills. A study by Amusa *et al*. (2010) of Grade 1 to Grade 5 learners in South Africa, reported that there were no meaningful gender differences for running speed and agility skills, but that gender differences did occur among Grade 6-learners. A possible reason why the girls could have done better than the boys in running speed and agility skills in the present study could be due to genetic and maturation factors, because speed and agility is a specific skill and is influenced by genetic factors (Marta *et al*., 2012). The running speed and agility skills of the boys could still be developing and for this reason the girls performed better (Gallahue & Ozmun, 2006; Pienaar, 2012).

Gender differences were shown with regard to balance skills in this study, where boys performed better in six (standing on one leg with open eyes, standing on a line with eyes shut, heel-to-toe walking, standing on one leg on a balance beam with open eyes, standing heel-to- toe on a balance beam and standing on one leg on a balance beam with eyes closed), of the nine balance skills. Several researchers (Al-Haroun, 1988; Malina *et al*., 2004; Lam, 2008) have indicated that girls do markedly better in activities that require balance than boys. The literature seems to suggest that gender differences already occur as early as age four to six in relation to balance, where girls also performed better (Toóle & Kretzschmar, 1993; Fjørtoft, 2000; Lejarraga *et al*., 2002; Lam *et al*., 2003; Sigmundsson & Rostoft, 2003; Venetsanou & Kambas, 2011). However, there are also contradictions in literature, since several researchers found no gender differences (Du Toit & Pienaar, 2002; Venetsanou, 2007; Kourtessis *et al*., 2008; Waelvelde *et al*., 2008).

The results furthermore indicated that most of the total number of learners sorted into the average skills category for strength (n=661, 76.59%), agility skills (n=547, 63.38%) and balance (n=482, 55.85%), while the second largest number of learners sorted into the above average category for strength (n=168, 19.47%) and running speed and agility (n=304, 35.23%), while 301 (34.88%) learners were in the below average category for balance skills.

These results are in contrast to the research of Mak *et al*. (2010) on 12- to 18-year-old children and the research of Volbekiene and Griciute (2007) on 12- to 16-year-old children that found that children have insufficient strength and agility skills. However, the mentioned research was conducted on older children and these researchers are of the opinion that a decrease in daily physical activity is the main contributing factor to these insufficient skills (Volbekiene & Griciute, 2007; Mak *et al*., 2010). A possible reason why the children in the present study performed better in the strength and agility skills items could be because several everyday activities rely on strength and agility skills to be executed (Fjørtoft *et al*., 2011).

Finally, the results of the present study show that there are relationships with small and large practical significance when considering strength, agility and balance skills. These findings are supported by the results of several researchers, who also found a relationship between strength, agility and balance skills (Ball *et al*., 1992; Wang & Chen, 1999; Baker

& Newton, 2008; Katic *et al*., 2012). Research by Katic *et al*. (2012), involving Croatian 10- to 14-year- old learners, found a positive relationship between balance, agility and strength, while Wang and Chen (1999) found a positive relationship between dynamic strength and balance, as well as dynamic and static strength in their research on 9- to 12-year-old learners.

In spite of these findings, there are contradicting findings in the literature on the matter of the relationship between strength, agility and balance. Kin-İşler *et al*. (2008), who studied 25- year-old professional basketball players, found no relationships between strength, agility and balance, while Muehlbauer *et al*. (2013) reported no meaningful relationship between strength, balance and mobility for 7- to 10-year-old children.

CONCLUSION AND RECOMMENDATIONS

The results of this study should be evaluated in the light of a few shortcomings picked up during the course of the study. The BOT-2 only evaluates certain aspects of physical fitness. A recommendation would, therefore, be that other test batteries be used as well to compile a complete physical fitness profile of the 9- to 10-year-old learners. A second recommendation is that body composition and socio-economic class differences be taken into account, since these factors could have an effect on the physical fitness of children (Duncan *et al*., 2008; McVeigh & Meiring, 2014; White *et al*., 2014).

Although the study had some shortcomings, the results showed that 9- to 10-year-old learners in the North-West Province had sufficient strength and agility skills, although this was not the case for balance skills. The study also revealed that there were gender differences with regard to strength, running speed and agility, as well as in the balance skills. Boys in general performed better than girls do with strength and balance skills, while girls did better in running speed and agility skills. It also came to the fore that there were relationships between the strength, running speed and agility and balance skills of these children. A follow-up study is recommended to determine whether the strength, running speed and agility and balance skills of these children will change with age.

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RELATIONSHIP BETWEEN BODY IMAGE AND SOCIO-ECONOMIC STATUS IN SOUTH AFRICAN ADOLESCENTS: PAHL-STUDY

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ABSTRACT

The aim of this study was to determine the body image (BI) and its relationship with socio-economic status (SES) among adolescents. The 15-year-old adolescents (N=287), consisting of 111 boys and 176 girls, were grouped according to SES. They completed the Body-Image Ideals Questionnaire (BIQ) to assess any discrepancy between ideal and perceived body image on a 4-point Likert-type scale. Cross products for each question were calculated, as well as a mean summarised body-image value for the BIQ. No significant differences for BIQ were found between boys and girls, but significant differences were found for body image between high and low SES with respect to weight, muscle tone, chest size and body proportion. A more pronounced discrepancy in body image was noted for higher SES than for low SES. In conclusion, adolescents of low and high SES perceived their body image significantly differently with regard to physical

appearance. Future interventions aimed to facilitate changes in body composition should take cognisance of these perceptions.

Key words: Body image; Adolescents; Socio-economic status.

INTRODUCTION

Body image (BI) is an important aspect of self-representation and self-evaluation throughout life. It is a multidimensional construct, defined most frequently as the degree of satisfaction about oneself with regard to size, shape and general appearance (Cash & Deagle, 1997; Bosi *et al.*, 2006). The self-discrepancy theory proposed by Higgins (1987) concerns people's emotional vulnerabilities and motivations that result from discrepancies in their patterns of belief about themselves. In addition, this theory states that a discrepancy between the actual self and the ideal/ought self, leads to discomfort and body dissatisfaction.

It is through body image that an individual maintains internal equilibrium, while interacting with the world, since this provides a person with a sense of identity and influences his or her behaviour (Santos & Sawala, 2000). As such, body image is intimately related to other aspects of body perception, such as self-concept, self-esteem, self-image, bodily concept and bodily scheme (Santos & Sawala, 2000). In general, body images impose the necessity for reflection on health and illness, socio-economic status (SES) and differing cultural beliefs and practices. South Africa is no exception. In the past decades, its people have faced challenges of epidemic proportions, such as obesity, underweight and HIV/AIDS, which have been

associated with specifically national perceptions. Many adults in the country perceive ample abdominal fat as a sign of wealth and success, for example, whereas a lean body creates the perception that a person may be malnourished or suffering from HIV or AIDS (Kruger *et al*., 2005; Armstrong *et al*., 2006).

Many factors influence the perception of body image. The subjective perception that individuals have of their body image may be more important to them than the objective reality of their appearance. The factors that have an effect include gender, age, ethnicity (Powell & Kahn, 1995; Puoane *et al*., 2005; Sano *et al*., 2008), and perceptions of physical appearance and cultural background (Dawson, 1988). Weight by itself, therefore, does not seem to be the only determinant in the level of satisfaction with one's personal body image (Davis & Claridge, 1998). The consequences of these various perceptions, as individuals try to improve their body image are associated, amongst other things, with eating disorders, depression, anxiety and risk behaviour (Johnson *et al*., 1984; Rosen *et al*., 1990; Kumanyika *et al*., 1993; Stevens *et al*., 1994; Kanayama *et al*., 2001).

Inconsistent results regarding connections between cultural preoccupation and socio-economic status on body image have been reported in the literature (Toro *et al*., 1989; Wardle & Marsland, 1990; Monteath & McCabe, 1997). One of the reasons, as concluded by Grogan (2008), is a lack of consistency in the classification criteria for SES. In addition, most studies have focused mainly on adults. Given that adolescence is a period during which physical appearance is emphasised and lifetime habits are formed, it was of interest to study the body image of adolescents from different SES.

In a review by Cohane and Pope (2001), it was reported that boys generally have fewer body image concerns than girls do. The dissatisfaction with body image is associated with low self- esteem and increased distress. Gender differences observed include the tendency for boys to aspire to be more muscular than they are and for girls to want to be thinner (Harrison & Bond, 2007). In the study by Rozin and Fallon (1988), adult men reported notable differences between their ideals and self-perceptions of body image, but these discrepancies did not necessarily imply dissatisfaction with their bodies. The argument presented was that men may understand more clearly that some of their ideals are unattainable, which makes them more content with their body image.

PURPOSE OF THE STUDY

There is little in the peer-reviewed literature on body image in adolescents of differing SES, especially in the South African context. Only one study could be found that reported a lower physical self-concept in obese children than in others whose weight was normal (Monyeki *et al*., 2009). The purpose of the study, therefore, was to determine and compare the body image of adolescent boys and girls of high and low SES and to establish whether a relationship between their body image (BI) and their SES exists. Knowledge about perceptions of BI among adolescents in differing economic circumstances will add new information, which could be of benefit when developing appropriately targeted interventions that focus on changing adolescent behaviour in ways that improve and maintain their health in the long term.

METHOD

Study design

This investigation is part of the Physical Activity and Health Longitudinal Study (PAHLS), which is a 5-year investigation into the development of physical activity and determinants of health risk factors among adolescents aged 14 to 18 years in selected high and low socio-economic areas in South Africa. Of the 8 high schools purposefully recruited in the Tlokwe Municipality of the North-West Province for participation in the PAHL-study, 4 were from a low socio-economic area and 4 from a high socio-economic area. 2 of the 4 selected high SES schools withdrew from participation without giving reasons except to say that they were not interested, leaving 2 that agreed to participate. Socio-economic classification followed the classification system currently used by the South African Department of Basic Education to categorise low to high SES schools in quintiles (Department of Education, 2003). The quintiles system (1–5) rank schools based on physical condition, facilities and crowding, and the relative poverty of the surrounding community. Baseline data were collected in 2010 and the data presented here are from the second year of data collection.

Ethical considerations

The Ethics Committee of the North-West University (NWU–0058-01–A1) granted ethical approval for the study.

Participants

A group of 287 (boys=111; girls=176) learners aged 15 years from the baseline sample of

400 learners initially recruited, participated in this study. The participants were boys and girls who were aged 14 years in 2010 and were either from an African or Caucasian descent and their parents had given informed consent for their participation. The ancestry of the learners was primarily Tswana and Afrikaans. Learners with physical disabilities were excluded from the study because of their inability to undergo the physical measurements that formed part of the larger PAHL-study, as described elsewhere (Monyeki *et al*., 2012).

Measurements

Demographic information regarding the date of birth of each learner and the locality of his or her school was obtained by means of a questionnaire. Body image was measured by means of the *Body-Image Ideals Questionnaire (BIQ)*, which was developed as a unique attitudinal body-image assessment that considers a person's perceived discrepancy from and degree of investment in personal ideals relating to multiple physical attributes (Cash & Szymanski, 1995).

During the completion of the questionnaires, participants were seated approximately 1m apart in a lecture room and no talking was permitted. To ensure anonymity, questionnaires were collected *en massé* in a large box as participants left the room.

The BIQ covers 11 physical attributes: height, skin complexion, hair texture and thickness, facial features, muscle tone and definition, body proportions, weight, chest (or breast) size,

physical strength, physical coordination and overall physical appearance. For each attribute, participants were asked to report how they actually perceived their body and then to consider what importance they would assign to each of these attributes. In Part A of the questionnaire, participants rated the extent to which they resembled or matched their personal physical ideal on a 4-point Likert scale, where 0="exactly as I am"; 1="almost as I am"; 2="fairly unlike me"; 3="very unlike me". In Part B of the questionnaire, participants indicated how important it was to them to resemble each physical ideal: 0="not important"; 1="somewhat important"; 2="moderately important"; 3="very important".

The mean BIQ score from the 22 items was calculated as the mean of all cross products of discrepancy (Part A) and importance ratings (Part B). These were computed after recoding all discrepancy ratings (Part A) from 0 to –1. This calculation permits extending the range of scores to include importance-weighted self-ideal congruence ("exactly as I am"), for each item. Otherwise, item cross-product scores would always equal 0 for self-ideal congruity regardless of the importance of the ideal for which the person reported matching the ideal. The potential range of these composite BIQ scores is –3 (for very important congruence across all physical attributes) to +9 (for very important and maximum discrepancies across all physical attributes). Higher scores reflect greater self-ideal disparity with strongly held physical ideals. Cash and Szymanski (1995) provide evidence in support of the incremental validity of multiple self-ideal discrepancies.

The reliability of the BIQ was verified before it was introduced to the participants, as the questionnaire had not previously been used in a South African context. The reliability was verified by means of the test/re-test technique, with a 4-day interval between test and re-test. The participants in the test/re-test were learners who attended the same schools as

those participating in the PAHL-study, but who were not themselves participants in the PAHL- study. The number of participants in the test/re-test procedure were 41 adolescents (girls=21; boys=20), aged 15 years. Cronbach's alpha for the questionnaire completed by the South African adolescents was acceptable (α=0.92). The data from the learners participating in the reliability tests were not used for any further analyses of this study.

Statistical analyses

Firstly, the data on the participants in the main study was analysed to determine the consistency of the BIQ for the 287 participants according to the BIQ manual (Cash, 2000). Results from the Cronbach's alpha analyses for internal consistency indicated an alpha of 0.77 was obtained. The item cross-product scores were calculated after recoding questions from Part A from 0 to –1 and multiplying scores from Part A and Part B item by item. Discrepancy scores, importance scores, as well as item cross-product scores were recorded in an ordinal scale; therefore, the median and percentiles were calculated. Since the BIQ is based on the 4- point Likert-scale, the Mann-Whitney U-test (non-parametric statistics) was used to establish the differences between boys and girls and between high and low SES. Item cross-product rating was done with the use of Friedman's ANOVA (non-parametric statistics). It was of interest to compare the results with the norms expressed as mean values reported for college men and women (Cash & Szymanski, 1995), thus the means and standard deviations for the summarised BIQ scores were also computed. Spearman correlation coefficients were computed for all 11 composite BIQ scores between the ideal BI (Part A) and the importance

of the BI (Part B) to examine relationships. Frequency analyses indicated the percentage adolescents per SES group for each BI category.

RESULTS

The descriptive results (Table 1) indicate that in this population there was a high discrepancy between perceived ideal and body image with regard to muscle tone and definition (M=2), as well as overall physical appearance (M=2). Higher congruence was observed in the skin complexion (M=0), hair texture and thickness (M=0) and facial features (M=0). The summarised BIQ indicate that the mean value for boys (0.69±2.01) was lower than that for the girls (1.07±2.18). When comparing the summarised BIQ scores, no differences were noted between girls and boys (z=–1.17; p=0.24), or between high and low socio-economic status (SES) (z=1.90; p=0.06).

TABLE 1. **DESCRIPTIVE VALUES OF ITEM CROSS-PRODUCT SCORES AND SUMMARISED VALUES: BODY-IMAGE IDEALS QUESTIONNAIRE (BIQ)**

BIQ	Mean±SD	Median	25th Perc.	75th Perc.
Cross-product scores (N=287)				
Height	0.73±3.15	1.00	–3.00	3.00
Skin complexion	0.59±3.24	0.00	–3.00	3.00
Hair texture and thickness	0.79±3.16	0.00	–2.00	3.00
Facial features	0.22±3.23	0.00	–3.00	2.00

Muscle tone & definition	1.35±3.62	2.00	–3.00	3.00
Body proportions	1.13±3.52	1.00	–3.00	3.00
Weight	1.47±3.84	1.00	–3.00	3.00
Chest size	0.78±3.11	1.00	–2.00	3.00
Physical strength	1.09±3.55	1.00	–3.00	3.00
Coordination	0.73±3.19	1.00	–3.00	3.00
Overall phys. appearance	1.29±3.58	2.00	–2.00	3.00
Summarised BIQ				
TOTAL (N=287)	0.93±2.12	1.00	–0.54	2.27
Boys (n=111)	0.69±2.01	1.09	–0.82	2.09
Girls (n=176)	1.07±2.18	1.18	–0.36	2.50

SD=Standard Deviation Perc.=Percentile

The results of the discrepancy ratings of BIQ reflecting the ideal body image (Part A of the questionnaire), indicated that the median for all the questions was 1 ("almost as I am"), except for the question on facial features that was reported as 0 ("exactly as I am"). The results of the importance rating (Part B of the questionnaire), indicated a median=3 (very

important) for questions 2, 5-7, 9 and 11. Calculations for the rest of the questions resulted in a median=2 (moderately important).

Significant high correlation coefficients ($p<0.05$) were found among all 11 composite BIQ scores (Table 2). No significant differences were noted between boys and girls and between high and low SES for Part A and Part B of the questionnaire.

TABLE 2. **SPEARMAN'S CORRELATION COEFFICIENT FOR ITEMS OF QUESTIONNAIRE**

BIQ items	Height	Skin complexion	Hair texture & thickness	Facial features	Muscle tone & definition	Body proportions	Weight	Chest size	Physical strength	Coordination	Overall phys. Appear.
Height	1.00										
Skin complexion	0.37	1.00									
Hair texture & thickness	0.31	0.29	1.00								
Facial features	0.32	0.41	0.19	1.00							
Muscle tone & def.	0.42	0.36	0.21	0.28	1.00						
Body proportions	0.38	0.27	0.20	0.37	0.42	1.00					

Weight	0.28	0.28	0.20	0.28	0.46	0.35	1.00				
Chest size	0.33	0.29	0.27	0.25	0.46	0.42	0.44	1.00			
Physical strength	0.36	0.36	0.24	0.32	0.45	0.35	0.39	0.31	1.00		
Coordination	0.43	0.30	0.28	0.29	0.42	0.38	0.38	0.38	0.48	1.00	
Overall phys. appearance	0.36	0.39	0.21	0.42	0.40	0.39	0.40	0.35	0.45	0.34	1.00

All correlations were significant at $p<0.05$.

The analysis of BIQ scores (computed as an item-by-item multiplication with the recoded 0 to –1 in Part A), turned out to be significantly different in the 4 questions. The BIQ showed a significantly higher discrepancy in the high SES group when considering muscle tone and definition (z=3.03, p=0.002), body proportions (z=2.58, p=0.009), weight (z=3.59, p=0.0002), and chest size (z=2.26, p=0.02). In all these questions the main differences were noted in the group that scored –3 (very important congruence) in the cross products of Part A and Part B (Figure 1). For 61 participants with low SES, the ideal muscle tone and definition matched their feelings about themselves, whereas there were only 11 participants from the high socio- economic group with the same match (Figure 1A). This trend was noticed for other questions

regarding body proportion (68 and 4 participants, respectively; Figure 1B), weight (66 and 7 participants, respectively, Figure 1C) and chest size (62 and 8 participants, respectively; Figure 1D).

DISCUSSION

The body image of adolescent boys and girls from high and low SES was determined. No gender differences between girls and boys were found when considering physical ideals, importance of physical features or self-ideal congruence. However, there were differences between high and low SES in four of the questions regarding self-ideal congruence.

One of the main findings is that, unlike reports in other studies by, for example, Moore (1990) and Stanford and McCabe (2002), there were no differences between boys and girls regarding body image. Some studies suggest that dissatisfaction and a preference for a thin body may start in girls as young as 5 years of age (Williamson & Delin, 2001). Tiggemann and Pennington (1990) noted differences between an "ideal" and "current" figure in 8-year-old Australian girls. Similar findings were reported in studies in Great Britain and the USA (Grogan, 2008). The fact that boys and girls in the present study did not differ significantly with regard to body image, is an indication that South African adolescents have a different view about body image than those in developed countries. Therefore, it may be surprising that no differences were found in our group of 15-year-old participants

In other studies, it has been reported that boys more often wish to be heavier than they are, rather than thinner (Hill *et al*., 1992). In a study by Ricciardelli and McCabe (2001), the majority of boys who were dissatisfied with their bodies wanted a larger body size. Boys normally idealise a muscular body shape more than girls do (Grogan & Richards, 2002).

Body dissatisfaction in adolescents, as well as body ideals, are strongly influenced by cultural pressure, especially in girls (Nichter, 2000). However, cultural influence does not make girls behave in a healthy way but, rather, encourages unhealthy methods of weight control (Nichter, 2000). In this study, body proportions, weight, muscle tone and definition, which may be considered with regard to body size and musculature, did not differentiate girls from boys.

Physical strength and coordination did not differentiate girls from boys either; these two features are strongly linked to muscularity, since they provide an appropriate context for sports abilities (Ricciardelli *et al*., 2006). The lack of difference between the South African boys and girls may be due to weaker cultural influence or, more likely, to different cultural patterns than those more common in Western developed countries. Adolescent girls and boys might not have been influenced by the expectation created through the media on what it is to be a woman or a man in Western society (Grogan, 2008), or they may have different cultural expectations of being a man or woman in their environment. Such a hypothesis may be supported by other findings of this study, namely the discovery that SES was an important factor affecting the body image satisfaction-dissatisfaction.

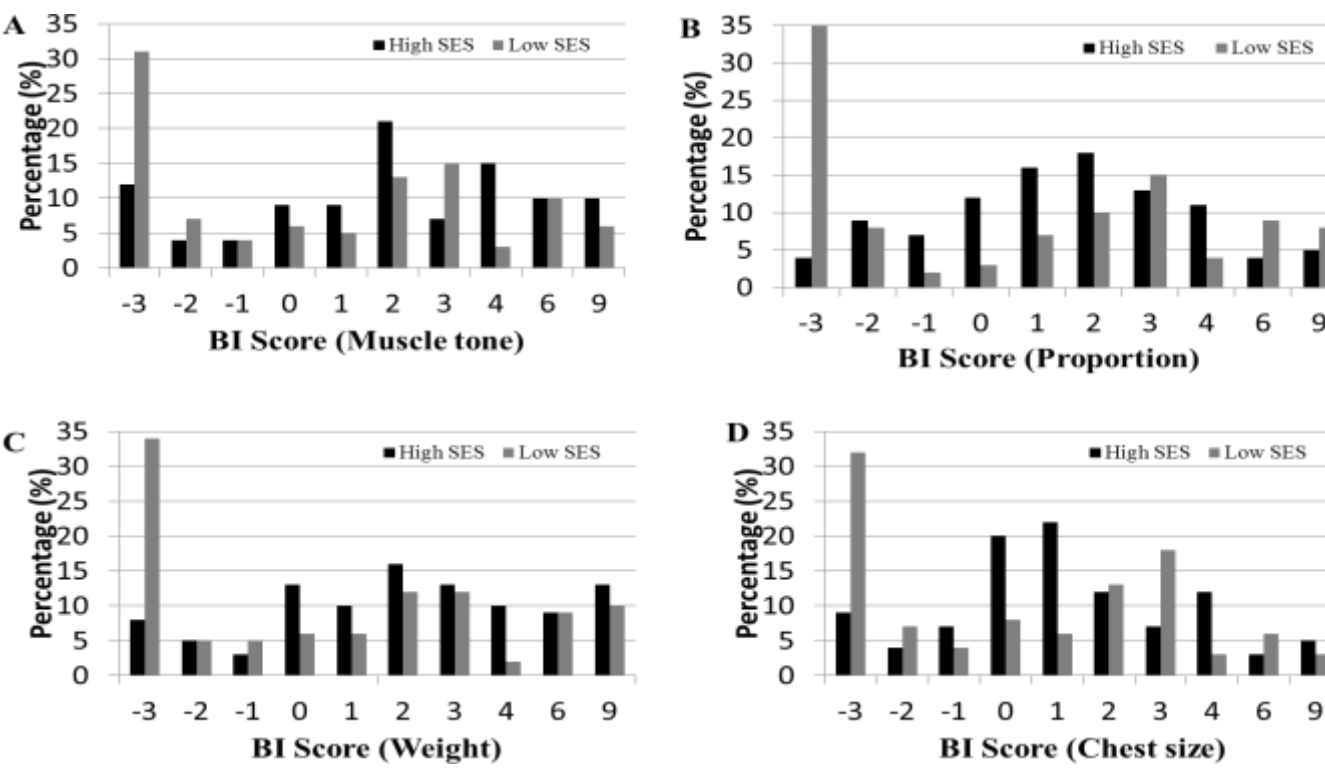

FIGURE 1. **PERCENTAGE SCORE: (A) MUSCLE TONE AND DEFINITION, (B) BO**
(C) WEIGHT AND (D) CHEST SIZE FOR LOW AND HIGH SOCIO-ECONOMIC ADOLESCENTS

The adolescents with high SES had higher discrepancy regarding muscle tone and definition, body proportions, height and chest size than those adolescents with low SES had. One could speculate that the adolescents with high SES were more westernised than those with low SES, which would make the effects noticed in their case and similar to those reported by other authors, namely high discrepancy when addressing musculature and body size. Regarding the current study, it may be worth mentioning that, SES in many cases could also reflect cultural representation. In the black culture (48% of the sample had Tswana ancestry), being overweight is traditionally symbolic of wealth, autonomy, attractiveness and happiness, while by contrast, in the Caucasian community (52% of the study sample had Afrikaans ancestry), lean body size is associated with beauty, health and happiness (Puoane *et al*., 2005).

The results of this study support the findings of Bordo (2003), in that Western cultures place greater pressure on people to be thin than other cultures do. It is most probably for this reason that dissatisfaction was higher in the high SES group. Although SES could be related to cultural influences, it is not possible at this stage to determine exactly what and how strong such a relationship might be.

There are some limitations to our study. The relatively small sample did not allow application of analysis of variance, in which gender, SES as well as ethnicity could have been included. It is very likely, however, that such analysis would further reinforce our current conclusions about ethnicity and cultural influence on body image. The classification of SES based on the quintile school attended, is a course sieve that provides blanket classification, since individual SES was not determined for each participant. These limitations should be addressed in future PAHL studies, where the longitudinal study design will allow estimations of how westernisation would affect adolescents from different socio-economic status and to what extent the body image discrepancy is influenced.

CONCLUSION

Adolescents with low and high socio-economic status, respectively, perceive their body image significantly differently with regard to physical appearance as represented by muscle tone, weight, chest size and body proportion. For this reason, educators and health-workers would do well to consider socio-economic status when planning and implementing health and physical activity interventions directed at addressing body shape and size. The differences in expectations about body image by adolescents from different SES should guide educators, social workers and physical activity educators to promote the desirability of a healthy body, and thereby reduce potentially undesirable consequences of a body image overly based on social acceptability.

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Disclaimer

Any opinion, findings and conclusions or recommendations expressed in this material are those of the authors and, therefore, the National Research Foundation and the Medical Research Council of South Africa do not accept any liability with regard thereto.

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COMPETITIVE ENGINEERING IN JUNIOR AUSTRALIAN FOOTBALL: PERCEPTIONS AND EXPERIENCES OF PARENTS, CHILDREN AND COACHES OF 9-A-SIDE FOOTBALL IN AN UNDER-8 COMPETITION

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ABSTRACT

Junior Australian Football leagues typically adopt rules and positional arrangements that mimic the adult version of Australian Football. This involves fielding 18 players per team on a full-sized oval. While such competition structures are appropriate for adult competition and elite athletes, modifications to field dimensions and number of players may be more appropriate for junior participants. A trial season of competitively engineered Australian Football was piloted by adopting the Australian Football League's (AFL) 9-a-side concept in an Under-8 competition for the first time. The 9-a-side trial occurred on Friday nights alongside the established Under 8's 18-a-side competition conducted on Sunday mornings. Participants in this study experienced both competition formats. A qualitative evaluation of the perceptions and experiences of parents, players and coaches of competitive engineering in junior Australian Football was done. The results indicate that the AFL 9-a-side concept provided an enhanced game experience emerging from (a) a high level of game engagement, (b) the game as an educative context, and
(c) an appropriate developmental step before the introduction of players to 18-a-side Australian Football.

Key words: Children; Australian Football; Competition engineering; Sport participation.

INTRODUCTION

While the Metropolitan Football League (MFL) were enthusiastic about better aligning the junior competition with Australian Football League (AFL) guidelines, the modification of rules and positional arrangements may also be a critical step in promoting continuation in Australian Football. Recent evidence suggests that the participatory nature of most youth Australian Football competitions do little to engage participants, leading to disengagement and subsequent withdrawal (Agnew *et al*., 2016). However, little is known about the consequences of competition engineering in this regard, because few youth Australian Football competitions have adopted the AFL match day guidelines. As such, there was a need to evaluate the participatory experience from the perspective of the players, parents and coaches.

Keeping children in sport

A central reason for the MFL enthusiasm towards the competition engineering from 18-a-side to 9-a-side was the belief that it would provide an improved participatory experience for players and enhance player retention (Agnew *et al.*, 2016). A recent review of children's sport dropout identified five main reasons why children withdraw from sport, including (1) a lack of enjoyment, (2) low perceptions of competence, (3) social pressures, (4) competing priorities and (5) physical factors, such as injuries and maturation (Crane & Temple, 2014). This extends previous research, which suggested that children and youth dropout from sport due to a lack of enjoyment and fun (Butcher *et al*., 2002). However, the reasons why children stay involved in sport appear to be attributed to reversed notions. For instance, Light *et al*. (2011) examined why children join and stay involved in sport clubs and concluded that social interactions contributed to a highly fun and enjoyable experience, which encouraged continuation tendencies. Therefore, notions of enjoyment and fun cannot be overlooked given that they remain central factors for not only young children, but also young adults who remain involved in organised sport (Jakobsson *et al*., 2014).

While notions of fun and enjoyment are clearly critical factors that influence dropout or continued involvement in sport, there is also a concern about the lack of coherence in terms of what constitutes enjoyment and fun that complicate understanding the implications of this factor for sport retention (Crane & Temple, 2014). Visek *et al*. (2014) address the matter of conceptual coherence concerning fun and enjoyment by proposing four fundamental constructs of fun in children's sport: *contextual* (practise and games), *internal* (learning and improving, trying hard, mental bonuses), *social* (team friendships, team rituals and being a good sport), and *external* (positive coaching, game time support and swag) imperatives. Visek *et al*. (2014) found that while all four constructs are important concepts relating to the notion of fun, the *contextual* construct emerged as the strongest determinant.

The *contextual* construct include aspects, such as the freedom to play creatively, play in tournaments, receive well-organised training sessions and playing time, and playing against evenly matched teams (Visek *et al.*, 2014). This reiterates previous assertions that children are able to experience high levels of enjoyment from being allowed to 'play' sport (MacPhail & Kirk, 2006), and reinforces the importance of engineering an engaging participatory experience for children. Therefore, although the social, internal and external constructs of fun and enjoyment are important, it is suggested that equal (and arguably more) attention should be given to the contextual construct, which reinforce fun and enjoyment from sport. This has direct implications for the nature of competition design, game rules and modifications to the playing experience to enhance the amount of fun children extract from participation.

Many sport competitions do not necessarily engineer playing conditions that meet the needs of child participants but rather conform to more traditional and 'adult' versions of sport. Concerns were expressed nearly 40 years ago, particularly as children's sport became increasingly 'professionalised' because of coaching practices that focused on competitive success in preference to notions of fun and enjoyment (Brower, 1979). Siegenthaler and Leticia Gonzalez (1997), also suggests that the professionalization of children's sport resulted from coaches who have trouble in making the distinction between children's need for patience, acceptance and sensitivity and their own need to emulate a professional coach.

More recently, studies also indicate that coaching practices continue to perpetuate a competitive discourse, suppressing a version of sport that is constructed for fun (Shields *et al*., 2007; LaVoi & Stellino, 2008; Walters *et al*., 2012).

Although coaches clearly play a central role in children's sport experiences, there is also growing advocacy for exploring the possibilities of modifying the contextual imperatives, which govern the way sport is played. This has been previously described as 'competitive engineering', which involves the modification of equipment, playing space and game rules to enhance children's game involvement, enjoyment and intrinsic motivation (Burton *et al*., 2011a; Burton *et al*., 2011b).

For instance, the study by Burton *et al*. (2011b) found that modifying game rules and equipment in flag football, scoring opportunities increased by 100% and attrition rates fell by 50%. As such, competitive engineering has real potential for encouraging sport participation, which can lead to enhanced intrinsic motivation and long-term sport involvement (Burton *et al*., 2011a; Burton *et al*., 2011b). The Australian sport "playing for life" philosophy foregrounds a form of competitive engineering for fun, enjoyment and an enhanced educative experience through its "change it" formula for games and sport modification (Schembri, 2005).

Participation pathways in junior Australian Football

Despite the potential advantages associated with competitive engineering in children's sport, with respect to junior Australian Football further modifications are possible as competition structures frequently do not align to the AFL match day guide, nor to the 'playing for life' philosophy. Typical pathways into junior Australian Football include early involvement in introductory programs such as Auskick. Auskick is a national programme for children aged 5 to 8 years that emphasises fun and safety, the improvement of basic football skills and personal responsibility. In terms of player involvement, Auskick is widely characterised by practises designed to develop technical skills such as kicking, hand passing and marking (Hickey & Fitzclarence, 2004). However, while Auskick programs are seen as integral to growing junior participation rates (Booth, 2007), encouraging retention as children progress into organised competition remains a significant challenge for the code (Hickey & Fitzclarence, 2004; Agnew *et al*., 2016).

The other traditional entry pathway into Australian Football is *via* participation in an organised competition. While the AFL junior match day guidelines encourage competition providers to modify game rules, such as contracting the size of the playing area and reducing the number of players on the field (AFL, 2012), there are concerns that many competitions ignore these guidelines and instead replicate a version of Australian Football that is more suited to adults and elite level participation (Agnew *et al.*, 2016). A secondary issue arising from the replication of adult forms of competition is that players are assigned positional roles based on coaches' perceptions of their playing ability as this maximises the likelihood of winning. Consequently, players who are perceived to possess less skill may be relegated to limited playing time or peripheral roles, limiting their game involvement and thus, capacity to develop and have fun (Walters *et al*., 2012).

PURPOSE OF THE STUDY

This paper presents findings and an analysis from a pilot project in a junior Metropolitan Football League (MFL) in South Australia. The pilot project involved re-engineering the playing experience by adopting modified rules and positional arrangements as recommended in the junior football match guide of the Australian Football League (AFL, 2012). At the completion of the season, the MFL approached the authors to conduct a qualitative evaluation of the perceptions and experiences of players, parents and coaches of the modified junior Australian Football experience.

A pilot season of junior Australian Football was evaluated whereby the AFL 9's concept was implemented in an Under 8's competition. The MFL continued to facilitate the established Under-8 competition on Sundays, which involved 18 players per team on a full sized ground, but also introduced a 9-a-side competition on Friday nights on a reduced playing space (Figure 1) as an additional trial competition format.

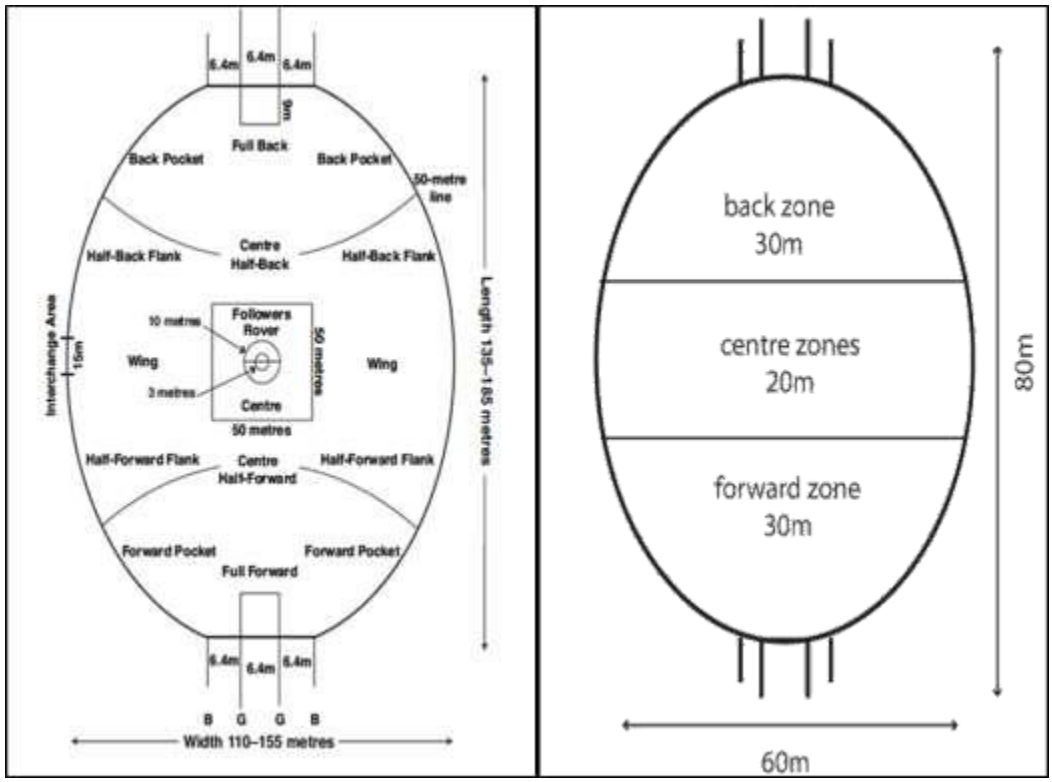

FIGURE 1. **POSITIONAL ARRANGEMENTS AND FIELD DIMENSIONS USED IN 18-A-SIDE (LEFT) AND 9-A-SIDE AUSTRALIAN FOOTBALL**

Four clubs fielded teams in both the Friday night and Sunday morning competitions. Consistent with the AFL junior match day guide, the 9-a-side competition was governed by

re-engineered game rules and playing space, distinguishing it from the traditional Sunday morning Under 8's competition as follows:

9-a-side: Friday night competition	18-a-side: Sunday morning competition
1. 9 players per team	
2. Games played on half of football oval	
3. 3 players positioned in each zone (forwards, midfielders, defenders)	
4. Coaches can be on the field during play	

1. 18 players per team
2. Games played on full football oval
3. No zones
4. Coaches cannot be on the field during play

METHODOLOGY

Nature of research

The purpose of evaluative research is to assist decision-making processes in relation to policies and programs through inquiry that describes and explains program operations and implications (Mark *et al*., 2000). In the current study, the purpose of the evaluation was to learn about the experiences and perceptions of competitive engineering in junior Australian Football. Specifically, a descriptive evaluative framework was employed whereby the focus included capturing the subjective experience or meaning experienced by participants (Mark *et al*., 2000). Furthermore, and consistent with evaluative research, this study adopted a sociological lens in the form of Social Constructionism. In evaluative research, Social Constructionism places an emphasis on the sharing and collaboration between the evaluator and those being evaluated (Grbich, 1998). In attempting to understand the perceptions and experiences of competitive engineering in the junior Australian Football setting (or context), it is, therefore, critical to capture this interaction, described by Gergen (1985) as a 'communal interchange' between humans and the context in the construction of meaning and knowledge.

While quantitative research approaches are traditionally characterised by empirical measures and the scientific notion of objectivity, qualitative research paradigms challenge the positivist stance by committing to understanding, with openness, the deeper underlying issues of a social phenomenon (Patton, 2002). It is the qualities of the latter approach, which are most significant to the objectives of this pilot program evaluation concerned with the perceptions and experiences of competition engineering in the form of 9-a-side Australian football. Subsequently, this qualitative evaluation utilises a case-study methodology in which parents, coaches and participants involved in the pilot study of the MFL Under 8‟s, 9-a-side competition bound the case under inquiry.

Participants

The 20 participants were purposefully recruited from the pilot 9-a-side competition to participate in an individual interview or focus group discussion (2 participants per group). Each focus group represented 1 of the 4 clubs involved in the 9-a-side competition, meaning that children and parents (in separate focus groups) shared their experiences with participants

from the same club. Overall, a total of 8 focus groups and 4 individual interviews were conducted.

The participants consisted of children aged 5 to 8 years (n=8), parents (n=8) and coaches (n=4). The participants were predominantly male, but female voices were captured in all

stakeholder groups. Most of the coaches were also parents of participants, but were identified as coaches for the purpose of this study. Collectively, the participants not only represented different demographic and socio-economic backgrounds, but also differing attitudes and backgrounds in sport more broadly. Some parents and coaches were new to junior Australian Football, while others were very familiar with the sport.

Procedures

Prior to data collection, institutional research ethics approval was attained and permission and cooperation from the MFL to conduct the research obtained. Following project approval, the MFL provided contact emails and phone numbers of each of the clubs involved in the 9-a- side pilot project. Once contact was established with each club, information sheets, introductory letters and consent forms were sent to each club for prospective participants to consider. The football clubs placed the documents in common areas for parents, children and coaches to access, at the request of the principal researcher. Some clubs placed the documents in high traffic areas such as the canteen and the football clubrooms for prospective participants to consider, while other clubs disseminated the packages directly to youth, parents and coaches on training nights. This process led to the organisation of 8 separate focus groups with parents and children, and 4 individual interviews with coaches.

Individual interviews and focus groups were utilised for data collection because they are effective in gathering rich, descriptive, cumulative and elaborate data (Lambert & Loiselle, 2008; Smith & Caddick, 2012). Smith and Caddick (2012) add that qualitative interviews and focus groups enable participants to direct the discussion, which is critical in producing dialectical depth. The duration of focus groups and individual interviews ranged from 10 minutes with children up to 80 minutes with parents and coaches. The vast difference in duration resulted from children's inability to elaborate extensively on their experiences in contrast to parents and coaches. The data was recorded using an audio-recording device.

A preliminary interview guide was developed based on interview guides previously used in evaluative research in youth Australian Football (Drummond *et al*., 2013). For example: *What are the best things about playing football? What have you enjoyed the most/least about football this season?* This assisted the research to adopt a guided line of inquiry (Patton, 2002), and to adapt it to suit the participants (scaffolding questions when working with 5 to 8 year old children).

Analysis of data

The textual data were manually transcribed verbatim and thematically analysed following the 6-step model of Smith and Caddick (2012). The 6-steps include phases of immersion, code generation, theme identification, theme review, theme labelling and definition and reporting of themes. Pseudonyms were used to conceal the identity of participants and their affiliated football clubs and league. To enhance methodological rigour, triangulation was applied in an

attempt to get what Silverman (2006) describes as a true fix on a situation by combining different perspectives. This was achieved, in part, by the nature of the participant cohort, which included multiple data sources (the voices of parents, coaches and children). To

enhance the trustworthiness of the findings further, inter-coder reliability techniques (Lombard *et al*., 2002) were employed, involving both authors independently coding a sample of focus group and individual interview data. This technique was undertaken with approximately 25% of the qualitative data, at which point both authors were satisfied with the sameness emerging from the independent coding process. The lead author coded the final 75% of the transcript data individually.

RESULTS

Throughout interviews and discussions with children, parents and coaches, a number of topics were canvassed in relation to the introduction of a 9-a-side Australian Football competition for Under 8's. From the data, 3 central themes emerged: game engagement and enjoyment; football as an educational context; and 9-a-side as an appropriate developmental step for 18-a-side football (Figure 2). Importantly, the experiences and perceptions surrounding 9-a-side Australian Football were unanimously positive, highlighted by the voices of children, parents and coaches in the ensuing section.

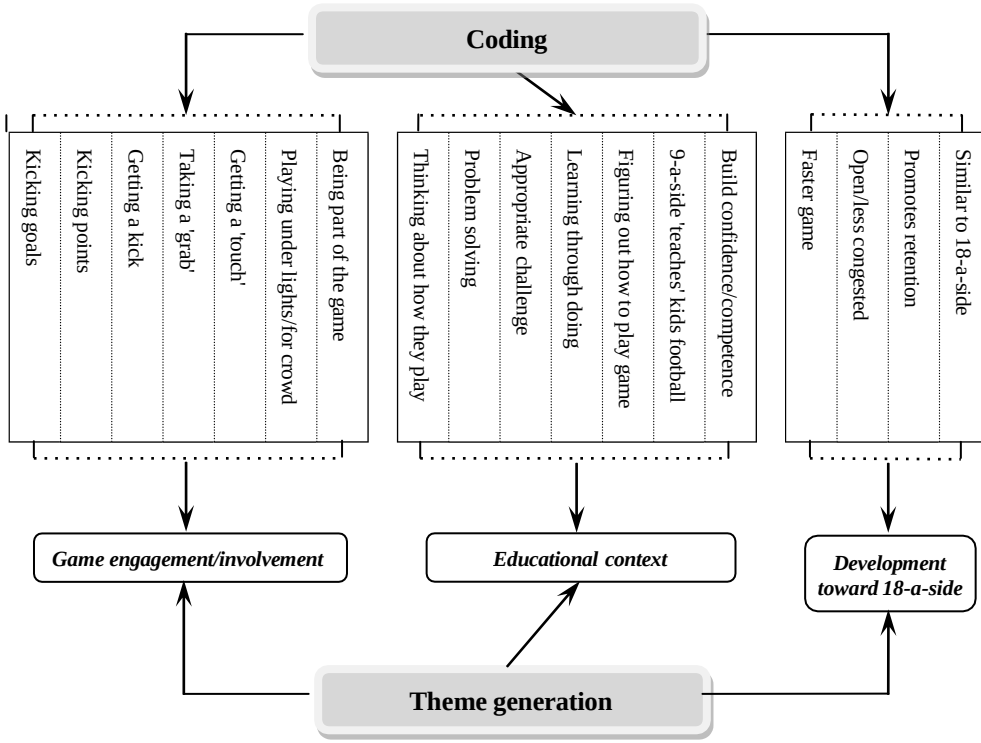

FIGURE 2. **A CODING TREE LEADING TO THEME GENERATION**

Game engagement and enjoyment

By participating in both 9- and 18-a-side junior Australian Football, children were able to compare playing experiences and share their thoughts on the 'new' style of 9-a-side footy. Positive perceptions associated with a higher level of game involvement in the 9-a-side

format emerged. As one child shared, "I enjoyed getting a few goals and running around going hard for the ball". One of the major issues with regard to the experience in 18-a-side football raised by children and parents was being positioned in peripheral roles where the player was least likely to touch the ball, such as the back and forward pockets. However, the 9-a-side format enabled **children** to feel „more involved in the game", reflected by the following group discussion:

I enjoyed getting a few goals, running and going in hard for the ball. [Tina]
I enjoyed kicking a goal. [Shaun]
Um, running around the oval.
[Toby] *Yeah – running around the oval.* [John] *Kicking goals and getting kicks.* [Shaun] *I kicked two goals in one game*. [Toby] *I kicked one goal*. [Shaun]
I kicked five. [John]

While children viewed increased game involvement as merely 'fun' and enjoyable elements of participation, parents and coaches perceived it as advantageous for children's football development. One **coach** reflected:

There were about 15 of our kids such as Tom who kicked five goals in one game and yet had probably only four kicks on a Sunday for the whole year. There were also twins who both kicked a couple of goals each in one game whereas on Sunday they are a bit overawed by the size of some kids and won't go in and get the ball a lot of the time, so 9-a-side has been fantastic. [Jason]

The coaches added that the combination of less players and a smaller playing field benefited children to gain possession of the ball with greater frequency and resulted in more scoring opportunities, which players enjoy. One **coach** summarised:

The main advantage that I have seen is that players can get a touch more easily than they can in 18-a-side competition. It was also easier to umpire because you have only 18 players in total on the field as opposed to 36 players, but just generally being able to get a touch. The kids found it a lot easier to get into it a lot of the time, but in the 18-a-side, due to having more numbers it's a lot harder to find the footy. [Robin]

The participatory experience in this regard was perceived to be widely beneficial. One parent also noted that the 9-a-side concept meets children's desire to 'touch the ball'. In 18-a-side games, the playing experience was perceived to be largely limiting due to player congestion around the ball, described as "bees to a honey pot" by one coach. Yet, in 9-a-side, children's

preferences for 'being involved in the game' were satisfied. This is exemplified in the following **parent** comment:

As I said, 9-a-side allows the kids to do the things they want. They want to kick

a goal and not get smashed by a big pack of kids. In the end, they wanted to participate in 9-a-side because it was fun. It is really hard to take a negative out of it honestly. As a parent, it was good to watch, seeing each kid get a kick and coming off the ground smiling. [Mary]

Educational context

Adult participants viewed the 9-a-side format as more than a sporting activity for children, but an educational context for playing and learning about the skills and thinking required to play Australian Football. A prominent perception among **parents** is exemplified in this extract:

Just watching them from week to week, playing 9-a-side, once they got started, they could really mix it with the rest of them on a Sunday. It helped them with their confidence levels and their ability to figure out how to go and get the ball, rather than watch their opponent run past them. [Colin]

While parents and coaches perceived similar competencies could be taught in 18-a-side Australian Football, they argued that 9-a-side was a more appropriate context for learning about concepts relating to offence and defence, playing 'team'-oriented football, and maintaining/dispossessing ball possession. The reduced number of players on the ground, coupled with positional 'zones' emerged as important in this regard, noted as leading to the development of numerous technical and tactical skills. One **coach** stated:

The 9-a-side teaches the back men that they have to look after their player at a young age rather than letting their opponent run around, which isn't always bad, but as you get older, you learn to run up, but as a junior, it just reinforces the fact that there are positions and that's where you learn to play. [Tim]

Another **parent** claimed:

On a personal level, my son had not kicked a goal up until he played 9-a-side and then all of a sudden, he figured out how to get to a position and kick a goal and from then on, you couldn't stop him! [Steve]

From the children's perspective, most did not observe the playing experience as 'educational', but rather an engaging sporting activity. However, according to 2 of the children, 9-a-side provided an appropriate challenge level for attacking when in possession with the ball. As such, 9-a-side helped these **children** develop thinking skills surrounding the best approach to kicking the ball to team mates.

It [9-a-side] was really good because we had more chance of touching the ball. It was also difficult because, not in a bad way, there were 3 players in each zone, and it was difficult to decide to whom to kick. Normally I would kick it to the person who doesn't have much people on them because the opposition team go and defend the taller players. [Wade]

Playing in a 9-a-side competition, children were perceived by adults to develop greater confidence in competing for possession and executing technical actions during games. Parents and coaches widely discussed notions of 'building confidence' as a result of touching the ball more frequently. This was perceived to influence the individual and the team positively. One focus group of **parents** discussed:

I mainly noticed in our team that the older one's helping the younger ones in the 9- a-side that got them all involved in the game, which is good, and they all came off smiling at the end of the day, which is what we want. [Sam]

Yeah, well my kid is only young and he didn't get much of the ball and that didn't really bother him but after doing 9-a-side, a couple of the older boys hand passed to him, wanted to help him, that's the team work we talk about. It all came together really well. [Barry]

The children claimed that they felt more competent as a result of playing in the 9-a-side competition. Some of the children made comments, such as "I can do it now" and "I know I can get a kick", demonstrating positive levels of confidence in relation to playing Australian Football. Others stated they not only felt more confident with playing the game, but also understanding the basic rules that governed play.

A developmental step toward 18-a-side Australian Football

By their own admission, many parents and coaches reflected on initial concerns about 9-a-side football prior to the trial competition commencing. Underpinning their concerns was a belief that 9-a-side was not 'real footy' because there were less players on the ground. However, attitudes of the parents and coaches changed significantly following observations of the nature and standard of games over the course of the season. Several parents commented that it was much more pleasurable to watch as a spectator because the game constantly 'moved'. In contrast, 18-a-side games in the Sunday competition were perceived to be 'more stagnant'. As one focus group with **parents** found:

It's not so congested on a Friday night (9-a-side). [Darren]

Not so scrappy yeah. [Ian]

The ball movement speed is pretty similar. The 9-a-side had a little bit more time to think, steady the kick, get it a bit more right and not rush it as much. [Kelly]

This distinction led to a high level of advocacy for the 9-a-side concept as an important developmental step toward playing 18-a-side football. As 1 parent suggested, "it would make sense to have Under 8's as 9-a-side, Under 10's as 12-a-side, Under 14's as 15-a-side – that might work well". However, parents and coaches who perceived children to favour the Friday night competition over Sunday morning 18-a-side football also supported advocacy for 9-a- side. As two **coaches** noticed:

Both games are very similar yet different with quicker ball movement in the 9-a- side. They moved the ball quicker on a Friday night than they do on a Sunday. Once the kids realised how fun Friday night was, they all wanted to play and have a go at it. It wasn't necessarily better ball movement, but it was quicker. [Ryan]

The enjoyment on the kids' faces after the games, they were stoked, they were happy and pumped and they were buzzing because they got heaps of the ball and they kicked a couple of goals – the kind of stuff that might be harder to do in the 18-a-side competition. [Tim]

For 1 **parent** in particular, 9-a-side was perceived to complement 18-a-side football by allowing children to develop their skills and understanding about the game, which then enabled them to participate in Sunday 18-a-side games with more confidence.

> *Sometimes in the 18-a-side, you have got bigger kids that are going for the ball so there are some kids who are a bit timid and stand out a little bit and don't get a touch, but then you see them getting a touch in the 9-a-side and the older kids helping them out – that's how you build confidence in each other. They started smiling and got to touch the ball and thought "we can actually do this" and I found they actually went in a bit harder and got the ball in the 18-a-side because they have already had that touch and know what it's about from the 9-a-side*. [Ian]

Overall, according to the children, parents and coaches, the 9-a-side concept in Under 8's Australian Football was positively received. Not only did it comprise a sport experience that demonstrated higher levels of game engagement and involvement, it also represented an educational construct for learning about the game and a developmental step appropriate for the age group.

DISCUSSION

The purpose of this study was to evaluate the perceptions of children, parents and coaches of competitively re-engineered experience in an Under 8's Australian Football competition. The re-engineering was characterised by a reduction in the number of players on a contracted playing space, and the modification of game rules. Previous research has found that competitive engineering can positively increase player's game engagement and decrease attrition in flag football (Burton *et al*., 2011a; Burton *et al*., 2011b). The current evaluation also suggests that competitive engineering in junior Australian Football, using the AFL 9's concept, has significant and positive potential for participants. Specifically, it was perceived to be a highly engaging game, a unique educative context for learning about Australian Football and an appropriate developmental step before the full version of 18-a-side Australian Football. Competitive engineering in this regard played a critical role in constructing a positively perceived experience as players, parents and coaches.

One of the important findings surrounding the 9-a-side concept was the high levels of fun and enjoyment that emerged from meaningful game engagement and involvement. In addition to spending time with peers, children found enjoyment from kicking goals, gaining ball possession and disposing of the ball by hand (handball) or foot (kick). The findings suggest that an authentic level of enjoyment emerged from children's ability to 'touch' the ball and contribute to the construction of play. This is consistent with the contention of Walters *et al*. (2012) that children extract immense and unparalleled enjoyment from being allowed to 'play' sport. However, in reality, it is likely that such experiences are constrained in many sport

settings whereby adult rules and structures prohibit high game engagement in children's and youth sport.

For some children, this may mean that they experience a marginalising introduction to organised sport. As such, coaches and sport providers may benefit from rethinking the organisational structure of competition and engineering a more engaging and enjoyable

framework for participation. In contrast, parents, children and coaches perceived the competitive engineering of the game experience in this project (Figure 2), as a more enjoyable participatory experience for players.

Another important finding was that 9-a-side represented a possible educational context through which children were able to learn about basic principles of play with respect to Australian Football. By participating in the competitively engineered football season on Friday nights, the children in this study expressed that they developed the confidence and capacity to perform with greater effectiveness in the Sunday 18-a-side competition. In addition to obtaining a greater frequency of possession, children learnt about concepts relating to attack and defence by being involved in more passages of play. In this way, competition engineering in junior Australian Football has the capacity to yield a distinct educative advantage for participants, which may encourage continued involvement. We suggest that this may offer the AFL and its affiliated junior competitions a complimentary yet educationally beneficial introduction to Australian Football, rather than relying primarily on Auskick programs which have historically struggled to successfully transition participants into organised competitions (Hickey & Fitzclarence, 2004; Agnew *et al*., 2016).

While there are clear developmental advantages associated with engagement in deliberate forms of play during the early years (Côté & Vierimaa, 2014), this study suggests that 9-a-side also comprises an educational context through which participants perceived gains in confidence and sport-related competence from learning about the basic principles of play in Australian Football. This arises from the decrease in player density around the ball in the 9-a- side compared to 18-a-side game format, providing players more time and space to think and act in the game, as well as have more time in possession as players "touch the ball" more often.

The findings further provide strong advocacy for 9-a-side as a representative, yet, developmentally important 'stepping stone' to more 'complete' adult iterations of Australian Football. The perceived benefits of competitive engineering in junior Australian Football may not only provide participants with a higher level of game engagement, which has positive implications for player development, but may also comprise a more fun and enjoyable sport experience. Such an approach to children's and youth sport may consequently have a capacity to disrupt traditional competition structures and coaching styles, which limit game play and subsequent game engagement.

PRACTICAL APPLICATIONS

Given that children want to play sport and be central to the experience (MacPhail & Kirk, 2006), the AFL 9's concept as an example of competitive engineering, appears to engender a promising initiative for junior Australian Football from an educative, developmental, and

motivational perspective. The findings support the notion of competition engineering, including a reduction of players in junior Australian Football as seen in a 9-a-side competition, as an appropriate intermediary step between skill development programs like Auskick, and organised 'adult' competitions. The findings provide further advocacy for competitive engineering, including the modification of rules, positional arrangements,

field dimensions, and number of players, particularly in junior sport competitions. This has implications for not only competition providers and leading sport organisations, but for coaches and parents who also play vital roles in facilitating children's sport.

CONCLUSIONS

Junior Australian Football leagues typically adopt rules and positional arrangements that mimic the adult 18-a-side version of Australian Football. This research evaluated parent, player and coach responses to a trial of the AFL 9-a-side concept adopted in an Under 8's competition for the first time. The 9-a-side trial occurred alongside the established Under 8, 18-a-side competition, but on a different day, meaning all the participants in this study experienced both competition formats. The qualitative evaluation found that participants considered that the 9-a-side Australian Football format provide players with an enhanced game experience due to: (a) a high level of game engagement; (b) an educational context; and
(c) an appropriate developmental step before the introduction of players to 18-a-side Australian Football, which was appreciated and even preferred to the common 18-a-side format by parents, players and coaches.

Further evaluative research is necessary to build the case for junior MFL adoption of the 9-a- side modified game format as the competition entry point for junior Australian Football, and the potential of additional competition engineering for game representation progressing from the "simple" 9-a-side format at entry level progressively through grades towards the full ground and full rules 18-a-side game format. Research of this nature investigating modified game progressions from entry to more developmentally advanced forms has occurred in other invasion sports (notably, soccer-association football), and may not only have great applicability for developing more robust programs in junior Australian Football, but for team sport programs generally where optimising game engagement and enjoyment is necessary.

It is also recommended that a longitudinal study tracking player and parent experiences of the progression of the competition engineering recommended in the AFL (2012) match day guide, from 9-a-side football at the point of competition entry to 12-, 15- and then 18-a-side on a full field. Such a study would address the long term effects of competition engineering on player engagement, retention at the critical period at the transition point from junior to youth football (Drummond *et al.*, 2013), as well as technical and tactical player-game development.

Acknowledgements

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Ethical clearance

An application for ethics clearance was submitted to the Flinders University Social and Behavioural Research Ethics Committee (ethics number 6570) for approval. Approval was attained in August 2014.

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NUTRITIONAL KNOWLEDGE AND STATUS OF COACHES IN VARIOUS SPORTING CODES

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ABSTRACT

Coaches have an important responsibility in the lives of athletes since athletes often use them as a source of advice for various performance-related issues, such as the nutritional regime. This descriptive study set out to identify the nutritional knowledge and nutritional status of coaches from various sport codes, as well as their nutrition recommendations for their athletes. The study included 165 individuals from different sporting codes i.e. team, strength, explosive power and endurance sports. Coaches were given a self-administered questionnaire with 76 questions. Most coaches had poor diet choices. For instance, the number of coaches who regularly consume vegetables, fruits and fish was low and most skipped meals attributable to limited opportunities and/or not feeling hungry. 76% of the 165 coaches alleged that they had sufficient knowledge about nutrition and 82% of the coaches provided knowledge about nutrition to their athletes. There was a significant difference among coaches of different sport codes in their recommendations concerning nutritional ergogenic supplements ($p<0.01$). The coaches of strength sport mostly recommended proteins/amino acid supplements. Coaches predominantly gave the correct or expected answer to both general nutritional knowledge and sport nutritional knowledge questions. However, the suggestions that coaches made to their athletes about training nutrition was inadequate.

Key words: Coaches; Nutritional knowledge; Nutritional status.

INTRODUCTION

Sports nutrition can be defined as the translation of nutritional knowledge into a practical daily eating plan focused on providing the energy for physical activity, facilitating the repair process following physical work and optimising athletic performance in competitive events, while promoting overall health and wellness (Fink *et al*., 2006). Research on the role of nutrition in exercise and sport has increased dramatically and, therefore, the scientific information in the field of sport nutrition is expanding rapidly. Today there is no doubt that nutrition plays a vital role in exercise performance and training (Manore & Thompson, 2000; Benardot, 2012).

Competitive athletes not only concentrate on their training to enhance their athletic performances but also place importance on their nutrition (Ersoy, 2011). It is known that insufficient and unbalanced nutrition may result in some health problems and poor performance and that athletes with a well-designed nutritional plan are more advantageous vis-a-vis those having an insufficient nutritional regime (Dobbe, 2005; Ersoy & Hasbay, 2008). The aim of optimal nutrition is to meet metabolic requirements and to provide the necessary energy and nutrients for the body (Yücecan, 2008). Optimising nutritional intake has been demonstrated to elicit peak performance levels from subsequent enhanced recovery, body mass control, effective hydration and reductions in illness and injury,

which coincide with increased confidence because of a more prepared mental state for competition (Cockburn *et al*., 2014). Consuming carbohydrate-rich food before, during and after training contributes to athletes' performance by helping to refresh the storages, which decrease during training or competition (Insel *et al*., 2004). It was also found that when carbohydrates and proteins (CHO/PRO: 3-4/1) were consumed together in the first three hours after competition, that the muscle protein synthesis rate was high (Fink *et al*., 2006; Howarth *et al*., 2009), which contributed to recovery (Nybo *et al*., 2013). Inadequate energy and nutrient intake may result in fatigue during the next training session if no effort is made in replacing the needed sources of nutrients (Dunford & Doyle, 2008).

To determine nutritional knowledge, daily food consumption records together with nutrition habit and status, sport dieticians/nutritionists may administer the questionnaires (Insel *et al*., 2012). Insufficient knowledge about nutrition and inadequate dietary practices could be limiting factors for sport, as well as exercise performance and recovery (Kruseman *et al*., 2008). It is, therefore, of utmost importance for elite athletes to have a reliable source of nutritional knowledge (Dobbe, 2005). In addition to the reliability of nutritional knowledge, athletes should also have easy access to reliable sources of nutritional knowledge. According to Torres-McGehee *et al*. (2012), coaches, fitness instructors and dieticians are the first sources of nutritional knowledge for athletes. As mentioned before, sufficient energy, food and fluid intake of elite athletes has a great impact on their competition performance and post-competition/exercise recovery (Dobbe, 2005). Therefore, the wide misinformation about nutrition among athletes makes it more and more crucial for sport instructors and coaches to be knowledgeable about nutritional regimes for athletes (Graves, 1991).

Athletes have sought advice from strength and conditioning coaches, dieticians, peers, family, media and independent research. However, Cockburn *et al*. (2014) found that coaches are the predominant source. Coaches have an important responsibility in the lives of athletes and athletes often use them as source of advice for different issues. Thus, coaches may influence athletes' energy and nutrient intake directly and should, therefore, acquire knowledge from reliable sources (Juzwiak & Ancona-Lopez, 2004; Zinn *et al*., 2006; Cockburn *et al*., 2014), and show that they possess adequate nutritional knowledge. Consequently, the aim of this study was to assess the level of nutritional knowledge and nutritional status of coaches from various sporting codes, as well as the dietary recommendations of coaches to athletes.

METHODOLOGY

Participants

Coaches (N=165) attending coaching courses throughout Turkey volunteered to take part in the study. The coaches coached different sporting codes (team, strength, explosive power and endurance sports), at different coaching levels (specifically levels 1 to 5). The first level is the beginner or entry level for nutritional education and nutritional topics include general nutritional knowledge, whereas the 5th level was the highest level for sport nutrition knowledge. The number of participants, which was originally 187, was reduced to 165 because some participants did not complete all the questions in the questionnaire. Of the 165 coaches that volunteered, 84.8% (n=140) were male, while 15.2% (n=25) were female. The average age of the males and females were 36±10 years and 32±9 years respectively, with coaching experience of about 8±7 years.

Procedure

The researcher interviewed coaches during the coaching courses. Erciyes University Medical Faculty Clinical Research Review Board in Turkey approved this study and all the participants provided written informed consent (2014/105). All participants took part on a voluntary basis with the option to withdraw at any time. The purpose of the questionnaires was thoroughly explained to the coaches by the researcher. Participants had the freedom to ask any questions during the completion of the questionnaire. Furthermore, any word or question that they did not understand was explained to them.

Sports Nutrition Knowledge Questionnaire

The questionnaire consists of 76 items. It was applied to individuals who coached in various sport codes with a view to identifying their nutritional knowledge, habits and nutritional status. The questionnaire contained 2 main sections.

A qualified dietician prepared the first section. The first section evaluated the demographics of coaches including age, education levels, whether they used to participate and/or whether they currently participate in any sport, the sport codes they coach, how many meals they personally have a day, the reasons why they might skip a meal, their fluid intake and their knowledge about nutritional ergogenic supplements.

The second part of the questionnaire comprised 20 sport nutrition knowledge questions about nutrition and diet (adapted from Güven *et al*., 2009), divided into 3 sub-categories: general nutrition (2 questions); nutrients (5 questions); and sports nutrition (13 questions). Each question could be answered 'TRUE' or 'FALSE', to discourage coaches from guessing answers and to allow differentiation between those possessing accurate and incorrect knowledge.

Statistical analysis

Statistical analyses were performed using the Statistical Package for Social Sciences (SPSS 15 Inc., Japan) for Windows. The level of significance was set at $p<0.05$. Descriptive statistics were used to summarise continuous variables using mean, standard deviations (SD) and frequencies. Chi-square (χ^2) tests were used to indicate differences among the sporting codes (specifically team, strength, explosive power and endurance sports).

RESULTS

Table 1 shows the distribution of coaches according to the 4 sporting codes. Of them, 72% (119) were university graduates and 27.9% (46) were high school graduates. The graduates from a School of Physical Education and Sport constituted 65.5% (108), while 8.4% (14) were in other professions. In terms of their current occupations, 87.3% (144) of the participants left this question unanswered. Some (8.5%; 14) were teachers and others stated that they worked in various fields. Of all the participants, 21% (34) were in the 1st coaching level, 31.5% (52) in the 2nd level, 29% (48) in the 3rd level, 10.3% (17) in the 4th level and 8.5% (14) in the 5th level.

TABLE 1. **COACHES ACCORDING TO VARIOUS SPORT CODES**

Sport codes	**n**	**%**

Team sports (football, basketball, volleyball, handball)	66	40.0
Strength sports (wrestling, boxing, taekwondo, weightlifting, judo)	34	20.6
Explosive power sports (gymnastics, table tennis, swimming, badminton)	29	17.6
Endurance sports (skiing, athletics)	36	21.8
Total	165	100

TABLE 2. **EXERCISE DURATION AND FLUID INTAKE OF COACHES**

Questions	**Sport codes**	**n**	**Mean±SD**	**F**	**p**
How many *DAYS* per week do you exercise? (only 127 exercised)	Team sports	#52	4.15±1.32	1.655	0.180
	Strength sports	#27	4.56±1.15		
	Explosive power sports	#17	3.65±1.22		
	Endurance sports	#31	3.97±1.76		
How many *HOURS* per week do you exercise? (only 127 exercised)	Team sports	#52	1.91±0.61	8.697	0.000*
	Strength sports	#27	2.28±0.88		
	Explosive power sports	#17	1.74±0.44		
	Endurance sports	#31	2.66±0.93		
How much *FLUID* (in litres) do you drink in a day?	Team sports	66	2.16±0.78	0.359	0.782
	Strength sports	34	2.07±0.87		
	Explosive power sports	29	2.22±0.88		
	Endurance sports	36	2.26±0.77		

* $p<0.05$ #= Only those who partake in exercise answered these questions (n=127)

TABLE 3. **COMPARISON OF COACHES IN VARIOUS CODES ACCORDING TO THEIR NUTRITIONAL HABITS**

Questions	**Answer**	**Sport Codes**				
		Team n (%)	**Strength** n (%)	**Expl. power** n (%)	**Endurance** n (%)	**T**
1. Do you eat vegetables and fruits regularly 5 times a day?	Yes	19(45.2)	10(23.8)	6(14.3)	7(16.7)	
	No	47(38.2)	24(19.5)	23(18.7)	29(23.6)	1
2. Do you eat fish regularly at least 2-3 times a week?	Yes	18(35.3)	9 (17.6)	9 (17.6)	15(29.4)	
	No	48(42.1)	25(21.9)	20(17.5)	21(18.4)	1
3. Do you eat more than 2-3 portions of red meat a week?	Yes	46(45.5)	14(13.9)	13(12.9)	28(27.7)	1
	No	20(31.3)	20(31.3)	16(25.0)	8(12.5)	
4. Do you go to a fast food restaurant (hamburger) more than once a week?	Yes	19(52.8)	4(11.1)	4(11.1)	9(25.0)	
	No	47(36.4)	30(23.3)	25(19.4)	27(20.9)	1
5. Do you eat dry legumes (dry beans, chickpeas, etc.) more than once a week?	Yes	51(36.7)	33(23.7)	22(15.8)	33(23.7)	1
	No	15(57.7)	1(03.8)	7(26.9)	3(11.5)	

6. Do you eat rice and pasta more than 5 times a week?	Yes No	32(38.6) 34(41.5)	15(18.1) 19(23.2)	15(18.1) 14(17.1)	21(25.3) 15(18.3)	
7. Do you eat oily nuts (pistachio, hazelnut, walnut) at least 2-3 times a week?	Yes No	43(36.8) 23(47.9)	27(23.1) 7(14.6)	21(17.9) 8(16.7)	26(22.2) 10(20.8)	1
8. Do you use olive oil at home?	Yes No	57(39.3) 09(45.0)	31(21.4) 3(15.0)	25(17.2) 4(20.0)	32(22.1) 4(20.0)	1
9. Do you consume 2 glasses of milk/yoghurt and/or 2 matchboxes (60g) of cheese a day?	Yes No	51(37.2) 15(53.6)	32(23.4) 2(07.1)	25(18.2) 4(14.3)	29(21.2) 7(25.0)	1
10.Do you consume desserts/candy a couple of times every day?	Yes No	32(38.6) 34(41.5)	16(19.3) 18(22.0)	15(18.1) 14(17.1)	20(24.1) 16(19.5)	

*p<0.05

Table 2 shows the coaches' status of exercise durations and their fluid intake. When participants were asked: "Do you ever skip meals?", 37.4% (37) of 99 participants who responded 'YES' to the question were the coaches of team sports, while 21.2% (21) were the coaches of strength and endurance sports. Lunch was in the first place (58%) and breakfast in the second (34%) in the ranking of the meal skipped. The 2 main reasons why they skipped meals were explained as not finding any opportunity and not feeling hungry.

The comparison of coaches in various sport codes according to their nutritional habits is summarised in Table 3. It was found that the percentage distribution of those who regularly ate vegetables and fruits every day and fish at least 2 or 3 times a week was low, whereas the number of those who consumed desserts/candies a couple of times every day was equal to those who did not. Similarly, the percentage of those who ate rice or pasta more than 5 times a week was equal to those who did not.

A significant difference was found among the groups in the answers they presented to the questions: "Do you eat more than 2 to 3 portions of red meat a week?" (p=0.002). When participants were asked: "Do you eat more than 2 to 3 portions of red meat a week?", 31.3% (20) of 64 participants who responded 'NO' to the question were coaches of team sports and strength sports, 25.0% (16) were coaches of explosive power sports, 12.5% (8) were coaches of endurance sports. Of the 101 participants who responded 'YES' to the question, 45.5% (46) were coaches of team sports, 27.7% (28) were coaches of endurance sports, 13.9% (14) were coaches of strength sports and 12.9% (13) were coaches of explosive power sports.

A significant difference was also found among the groups regarding their answer to the question: "Do you eat dry legumes (dry beans, chickpeas, red beans, etc.) more than once a week?" (p=0.02). When participants were asked: "Do you eat dry legumes (dry beans, chickpeas, red beans, etc.) more than once a week?", 36.7% (51) of 139 participants who responded 'YES' to the question were coaches of team sports, 23.7% (33) were coaches of strength sports and endurance sports and 15.8% (22) were coaches of explosive power sports.

When participants were asked "Do you eat dry legumes (dry beans, chickpeas, red beans, etc.) more than once a week?", 57.7% (15) of 26 participants who responded 'NO' to the question were coaches of team sports, 26.9% (7) were coaches of explosive power sports, 11.5% (3) were coaches of endurance sports and 3.8% (1) was a coach of strength sports.

Only 13.3% (22) of the coaches stated that they used nutritional ergogenic supplements themselves, mostly multivitamins (15) and proteins (7). 59% of those who used ergogenic supplement stated that they used them on their own initiative, whereas 18.2% used them on the advice of a physician and 13.6% on the advice of another coach.

In response to the question, "Do you have any knowledge about sport nutrition?", 76.3% (126) of participants said 'YES', while 23% (38) responded "not at a sufficient level". There was no significant difference among the sporting codes ($p>0.05$). The top 3 sources of knowledge were listed as school (48.4%), coaching training seminars (36.3%) and books (9.1%). 82% (135) of coaches stated that they provided their athletes with knowledge about nutrition. There was a significant difference between the coaches of the various sport codes

recommending nutritional ergogenic supplements ($p<0.01$) (Table 4). The coaches of strength sports mostly recommend proteins/amino acid supplements.

TABLE 4. **COMPARISON: RECOMMENDATIONS ABOUT NUTRITIONAL ERGOGENIC SUPPLEMENTS BY COACHES OF VARIOUS SPORT CODES**

Question: *Do you recommend nutritional ergogenic supplements to athletes?*							
	Sport codes						
Answer	**Team** n (%)	**Strength** n (%)	**Expl. power** n (%)	**Endurance** n (%)	**Total** N	**χ^2-Value**	**p-Value**
Yes	10 (21.7)	21 (45.7)	4(08.7)	11(23.9)	46	27.724	0.000*
No	56 (47.1)	13 (10.9)	25(21.0)	25(21.0)	119		
Total	66 (40.0)	34 (20.6)	29(17.6)	36(21.8)	165	*p<0.05	

In response to the questions, "What do you recommend your athletes to eat as the last main meal before the exercise" and "What do you recommend to them for their nutrition during and after the exercise?"**,** the most common answers were a meal that contains complex carbohydrates and carbohydrates and proteins together for the pre-exercise period, water and sport drinks during the exercise and plenty of water and fruits for the post-exercise period. No significant difference was observed among the groups in terms of the answers to the questions ($p>0.05$).

An analysis of the percentage distribution in terms of giving the expected answer to the nutrition knowledge questions revealed that most of them gave the expected answers. Among the groups, significant differences were observed only in the response to the statement, "Food that are rich in carbohydrate should be eaten in the recovery period" ($p=0.04$), and to the statement, "Fluid intake should stop 1 hour before the competition" ($p=0.03$) (Table 5). There were significant differences between the groups in their response to the statement, "Fats are the most important nutrients to boost the performance", according to the coaching levels.

It was found that the percentage of expected answers given by the coaches in levels 1 to 3 was higher than that of the others. However, the different coaching levels did not lead to any significant difference in their answers to the questions about nutritional knowledge in this study.

	Questions	Answer	Sport Codes Team n (%)	Strength n (%)	Expl. power n (%)	Endurance n (%)
1.	A sufficient and balanced diet is fundamental to a healthy life.	True	61(38.6)	34(21.5)	27(17.1)	36(22.8)
		False	5(71.4)	0(00.0)	2(28.6)	0(00.0)
2.	4 basic nutrient groups are the meat group, milk group, cereals and fruits & vegetables.	True	58(39.2)	29(19.6)	28(18.9)	33(22.3)
		False	8(47.1)	5(29.4)	1(05.9)	3(17.6)
3.	Bread, rice and pasta are rich in carbohydrates.	True	62(39.7)	34(21.8)	25(16.0)	35(22.4)
		False	4(44.4)	0(00.0)	4(44.4)	1(11.1)
4.	Vegetables and fruits are rich in proteins.	True	25(46.3)	6(11.1)	11(20.4)	12(22.2)
		False	41(36.9)	28(25.2)	18(16.2)	24(21.6)
5.	Liver and meat are a good source of vitamin C.	True	9(50.0)	4(22.2)	4(22.2)	1(05.6)
		False	57(38.8)	30(20.4)	25(17.0)	35(23.8)
6.	Iron is a nutrient that causes anaemia.	True	45(37.8)	24(20.2)	24(20.2)	26(21.8)
		False	21(45.7)	10(21.7)	5(10.9)	10(21.7)
7.	Calcium is necessary for bones and dental health.	True	61(38.6)	33(20.9)	28(17.7)	36(22.8)
		False	5(71.4)	1(14.3)	1(14.3)	0(00.0)
8.	Vitamins and minerals are the basic nutrients that provide the body with energy.	True	41(42.3)	17(17.5)	14(14.4)	25(25.8)
		False	25(36.8)	17(25.0)	15(22.1)	11(16.2)
9.	Fats are the energy source that the body uses primarily.	True	27(48.2)	13(23.2)	9(16.1)	7(12.5)
		False	39(35.8)	21(19.3)	20(18.3)	29(26.6)
10.	Carbohydrates are the most convenient energy source for athletes.	True	55(39.0)	29(20.6)	25(17.7)	32(22.7)
		False	11(45.8)	5(20.8)	4(16.7)	4(16.7)
11.	The last main meal should be eaten at least 3 hours before the exercise/competition.	True	55(37.9)	32(22.1)	26(17.9)	32(22.1)
		False	11(55.0)	2(10.0)	3(15.0)	4(20.0)

Continued on next page

(*cont.*)

Questions	Answer	Sport Codes Team n (%)	Strength n (%)	Expl. power n (%)	Endurance n (%)
12. Dry beans, rice and yoghurt are a convenient menu before an exercise or a competition.	True	18(42.9)	10(23.8)	7(16.7)	7(16.7)
	False	48(39.0)	24(19.5)	22(17.9)	29(23.6)
13. Food rich in carbohydrate should be eaten during the recovery period.	True	45(36.0)	23(18.4)	26(20.8)	31(24.8)
	False	21(52.5)	11(27.5)	3(07.5)	5(12.5)
14. It would be a good choice to consume chocolate bars, cakes and coke right after an exercise or a competition in order to accommodate the need for energy.	True	15(53.6)	6(21.4)	4(14.3)	3(10.7)
	False	51(37.2)	28(20.4)	25(18.2)	33(24.1)
15. Fluid intake should stop in one hour before the competition.	True	15(26.8)	14(25.0)	9(16.1)	18(32.1)
	False	51(46.8)	20(18.3)	20(18.3)	18(16.5)

16. Having sports drinks would be an advantage in long-term exercise.	True False	40(37.4) 26(44.8)	23(21.5) 11(19.0)	21(19.6) 8(13.8)	23(21.5) 13(22.4)
17. When the fluid loss due to perspiration reaches 2% of the body weight, performance is adversely impacted.	True False	45(38.1) 21(44.7)	24(20.3) 10(21.3)	25(21.2) 4(08.5)	24(20.3) 12(25.5)
18. Fats are the most important nutrients to boost the performance.	True False	23(53.5) 43(35.2)	10(23.39 24(19.7)	6(14.0) 23(18.9)	4(09.3) 32(26.2)
19. Vitamin and mineral tablets are ergogenic elements athletes use to increase their performance.	True False	41(35.7) 25(50.0)	23(20.0) 11(22.0)	22(19.1) 7(14.0)	29(25.2) 7(14.0)
20. In order to increase the muscle mass, one should take proteins more than the amount actually needed.	True False	40(41.2) 26(38.2)	18(18.6) 16(23.5)	18(18.6) 11(16.2)	21(21.6) 15(22.1)

[a] Proportion of the number of cells less than 5 to total cell number is more than 20% [b] Expected answer *p<0.05

DISCUSSION

The study revealed that 65.5% (n=108) of the participants were graduates from a School of Physical Education and Sport and the sport codes they used to participate in were mainly team sports (40%). There was no significant relationship between the sporting codes they coach currently and those they participated in previously. Overall nutritional knowledge of most coaches were sufficient, however, their own nutritional habits were not appropriate.

A linear relationship was expected between coaching levels and healthy nutritional habits. However, the different coaching levels did not lead to any significant difference in their answers to the questions about nutritional habits in this study. These results can be deduced because, despite the increased nutrition education of coaches in this study, they may not change the present nutrition habits. Bayraktar and Yaman (2002) found some significant difference in nutritional habits among different coaching levels in different sporting codes. It was found that the percentage of expected answers given by the coaches about healthy nutritional habits was higher for third level coaches than first and second level coaches.

It was seen that the percentage distribution of those who regularly consume vegetables and fruits every day and those who eat fish at least two to three times a week was low. However, the number of those who ate desserts and candies for a couple of times every day was equal to the number of those who did not. The percentage of those who ate rice and pasta five times a week was nearly the same as the number of those who did not. A significant difference was observed among the groups in the answers to the questions "Do you eat red meat more than two to three times a week?" and "Do you eat dry legumes (dry beans, chickpeas, red beans, etc.) more than once a week?". Coaches of team sports and endurance sports ate red meat more than two to three times a week. Coaches who ate dry legumes (dry beans, chickpeas, red beans, etc.) more than once a week were 84.2% (139) of 165 participants.

These results indicated poor diet choices of most coaches, even though they perceived themselves as having adequate nutritional knowledge (Table 5). A study by Bayraktar and Yaman (2002), found that there was no significant difference in nutritional status of the coaches (handball-taekwondo and handball-gymnastics). In another study, it was found that

nutritional behaviours of gymnastic coaches were different from those of some other sporting code coaches (swimming, basketball, volleyball). Because gymnastic coaches generally want to be lean, they especially pay attention to body weight. Therefore, their nutritional behaviours may be different from other sport codes (Heffner *et al*., 2003). However, there were no differences among coaches of different sport codes in the current study.

Most of the coaches indicated that they think they have knowledge about sport nutrition. Schools (48.4%), coaching training seminars (36.3%) and books (9.1%), were listed as the top three sources of nutritional knowledge. The first ranking of the school in this list can be explained by the fact that most of the participants were graduates from the School of Physical Education and Sport, where they took a compulsory course in sport nutrition. Yıldıran and Bayraktar (2002) state that the top three sources of knowledge for coaches were books (18.9%), schools (18.9%), nutrition experts and dieticians (14.2%), and coaching courses

(14.2%) (Yıldıran & Bayraktar, 2000). Another study revealed similar results (seminars, schools and coaching courses) (Çınar *et al*., 2009).

Dobbe (2005) found that most coaches were interested in learning about sport nutrition. In addition, other research with similar findings also report that the primary source of nutritional knowledge for athletes was mostly coaches (Burns *et al*., 2004; Sajber *et al*., 2013). Dobbe (2005) suggests that the source of nutritional knowledge for sportsmen was mostly the coaches, whereas it was dieticians and school courses for sportswomen. In the current study, 81.8% (n=135) of the participants said they provided their athletes with knowledge about nutrition. Training topics mostly included a sufficient and balanced diet, ergogenic supplements and nutrition during the exercise/competition periods. Yıldırım *et al*. (2008) found that 58.1% (250) of 430 coaches made nutritional recommendations to their athletes and the recommendations were mostly on sufficient and balanced diets (54.8%), and nutrition before and after exercise/competition (17.6%). Another study revealed that the most common problem coaches identified, regarding their athletes, was an insufficient and unbalanced diet based mainly on fast food (Corley *et al*., 1990).

Body weight and composition are important factors for performance not only in sport codes that are subject to weight classifications, such as boxing, wrestling and weight-lifting, but also in other codes such as gymnastics, running and cycling. It is, therefore, of great importance for coaches to be knowledgeable on this issue (Turocy *et al*., 2011). Many athletes often need knowledge about prevention of fatigue (Şenel *et al*., 2004), increasing their performance, ergogenic supplements and weight control (Burns *et al*., 2004). Consequently, coaches could influence the nutritional behaviours of athletes directly. It is, therefore, important that coaches have correct nutritional knowledge from reliable sources such as registered dieticians, nutritionists and exercise physiologist.

In this study, there was a significant difference among coaches of different sport codes providing knowledge about nutritional ergogenic supplements. Coaches of strength sports mostly recommended protein and amino acid supplements. Another study supports the fact that coaches (58%) recommend nutritional supplements (Kruseman *et al.*, 2008). In a study on strength sport coaches (63 males, 30 females), it was found that all of the males and 47% of the female coaches stated that they gave a diet program to those whom they were

coaching. However, only male coaches (62%) recommended anabolic steroids (Jazayeri & Amani, 2004).

It is a basic objective for an athlete to sustain his or her energy balance. Carbohydrates are the main nutrients that provide the energy needs, and have a critical role particularly in high intensity long-term exercises. Especially, before an exercise, it is recommended to consume some food containing low fat and fibre, proteins at medium levels and rich in carbohydrates but with a low Glycaemic Index. As the duration and intensity of exercise increases minerals are lost. Sport drinks may be useful in long duration exercises since the sport drink replace mineral loss. Even if it is known that carbohydrates with a high Glycaemic Index ensure better saturation in glycogen storage, it is useful to consume 3 to 6g essential amino acids in order to increase the protein synthesis after the exercise (Fink *et al*., 2006). In the current study, in response to the question, "What do you recommend your athletes as the last main meal before, during and after the exercise?", the two most common answers for the pre-

exercise period was: a meal that contains complex carbohydrates and a meal that contains carbohydrates and proteins together; during exercise, water and sport drinks; and for the post- exercise period, plenty of water and fruits. No significant difference was observed among the groups in the answers to the questions. Carbohydrate and protein should be recommended by coaches especially after training. Other researchers state that coaches make recommendations mostly before the competition and recommend food rich in protein but poor in fat, whereas they do not make any special recommendation for the exercise period (Juzwiak & Ancona- Lopez; 2004). Although the main source of energy for athletes is carbohydrates, Juzwiak and Ancona-Lopez (2004) report that coaches recommend food rich in protein for gymnastics, tennis, swimming and judo.

Most of the participants knew what the four main nutrient groups were (89.7%), and that food such as rice, pasta and bread were rich in carbohydrates (94.5%). The percentage was high for those who gave the expected answers to questions about nutrition before, during and after a competition and knowledge about fluid and sport drink intake. The percentage who gave the answer, 'TRUE', to the question, "In order to increase the muscle mass, one should take proteins more than the amount actually needed" was high (58.8%), which suggest that there is limited nutritional knowledge. Although a previous study has shown that 96.8% of coaches did not know that minerals are essential nutrients and 88.2% of coaches did not know that water is an essential nutrient (Jazayeri & Amani, 2004). Another study has shown that the coaches emphasised that carbohydrates are the primary energy sources and food rich in protein should not be consumed in the last main meal right before a competition (Yıldıran & Bayraktar, 2000). This indicate the limited knowledge of coaches and that each coach had different nutritional knowledge.

Most coaches gave the expected answers to both general nutritional questions (excluding the eighth question), and sport nutrition questions (excluding the twentieth question). There were significant differences between the groups only in the answers given to the questions, "Food rich in carbohydrates should be consumed in the recovery period" and "Fluid intake should stop one hour before the competition". The rate of the answer 'TRUE' of coaches of team and endurance sports was higher on the question, "Food rich in carbohydrates should be consumed in the recovery period" than coaches of strength and explosive power sports. Most of the coaches of strength and explosive power sports answered "protein" to this

question. This could be because these coaches believed that protein was more effective for muscle mass and muscle tissue repair than carbohydrates for strength and explosive power athletes. The rate of the answer, 'FALSE' of team sport's coaches was higher for the question, "Fluid intake should stop one hour before the competition", than the other coaches.

There was a significant difference between the groups in their response to the statement, "Fats are the most important nutrient to increase the performance", according to the level of coaching. It was found that the coaches in the first three levels tended to give the expected answer more than the others did. However, the levels of coaches did not lead to any significant difference in their answers to the questions about nutritional knowledge in this study.

Various studies conducted previously with the aim to determine coach's nutritional knowledge level found that the coaches had insufficient knowledge about nutrition (Sossin *et*

al., 1997; Yıldıran & Bayraktar, 2000; Shifflett *et al*., 2002; Çongar & Özdemir, 2004; Zinn 2004; Kruseman *et al*., 2008). Some other studies showed that they gave correct answers to the nutritional knowledge questions and, therefore, they had a sufficient knowledge level (Bedgood & Tuck, 1983; Pantano, 2006; Smith-Rockwell *et al*., 2011; Torres-McGehee *et al*., 2012).

CONCLUSIONS

This study aimed to assess the nutritional knowledge levels and nutritional habits/status of coaches who play an important part in the lives of athletes and the recommendations they gave to their athletes. Nutritional knowledge of most coaches was sufficient since most coaches gave the correct answers to both general nutritional knowledge questions and sport nutritional knowledge questions. Nevertheless, nutritional habits of most coaches were insufficient. Coaches provided their athletes with knowledge about nutrition specifically about sufficient and balanced diet, ergogenic supplements and nutrition during the exercise/competition periods. Coaches of strength sports mostly recommend proteins/amino acid supplements compared to the other sporting codes. Although coaches said they had knowledge on sport nutrition and they gave the expected answers to sport nutrition questions, they did not recommend accurate knowledge about training session nutrition to their athletes. It is important that coaches have correct knowledge. Therefore, the knowledge sources of coaches must be reliable, such as registered dieticians, nutritionists and exercise physiologists. The coaches should be properly educated in nutrition by sport dieticians, nutritionists and exercise physiologists. More nutritional knowledge questions can be researched in future studies.

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EXPERIENCES OF FAMILIES WITH A HIGH-ACHIEVER CHILD IN SPORT: CASE STUDIES

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ABSTRACT

The family, not only the coach, plays a major role in the pursuit of children to reach the highest level in sport. Yet, it is mainly the high achiever, and sometimes the coach, who get recognition for success in this regard. This study explored the experiences of families with high-achieving adolescent athletes aspiring to compete in the Olympics. The participants consisted of three purposively selected South African families. In-depth phenomenological interviews were conducted. Data were analysed by means of thematic coding. Four themes were identified: a child who is an achiever in sport affects the whole family; acceptance of the trying circumstances of being a high achiever in sport made it easier for the achiever child to cope; as siblings grow older, they try to find their own niche in the family; and coaches become as important to children as their own parents. A cross-validation report of the three case studies and a discussion of findings in the literature give insight into an understanding of the everyday lives of high achievers in sport.

Key words: Sport family; Family life; High achiever in sport; Acknowledgement of parents; Parenting sport stars.

INTRODUCTION

Sport has become a major international focus as it transcends language, social, cultural, religious, financial and political barriers. When the World Cup fever hit South Africans in

2010, it was all about the players and coaches. The same happens when one watches the winners' podium in other major sporting events. Nevertheless, Bert le Clos, father of Olympian, Chad le Clos, changed this at the London Olympics in 2012. His emotional words about his son's victory over Olympic champion, Michael Phelps: "unbelievable ... unbelievable!", instantly made him a worldwide celebrity (Balding, 2012).

Ekern and Cooper (2013), Siekanska (2013), McCarthy (2014) and the Palo Alto Medical Foundation (2014), report that parents and coaches have the most influence on athletes. Sam Ramsamy (2003), president of the South African National Olympic Committee at the time, said that the support of the family often goes unnoticed. The sporting ambitions of one or more of the children often dominate the life of the entire family (Grisogono, 1991). Some parents even make it their life mission to help develop their children's sporting talent.

The research of Siekanska (2013) emphasise the importance of parental support in their children's sport involvement. However, few authors have attempted to study the dynamics of the family, or how it is affected by the participation of the child. Investigations into home influence have provided only limited information on how families create, sustain and communicate their own realities when one of the family members is committed to high-level performance. An Internet discussion on coaching middle-distance runners (Coaching middle distance runners: Psychology, 2014), confirmed that much has been written and said about the roles of coaches and their responsibilities concerning these runners, but that little is mentioned about the role of parents and the rest of the family.

Côtè and Hay (2002, cited in Delforge & Le Scanff, 2006), highlight the developmental age stages of young athletes and how they affect the lives of the families and athletes, as well as the role of parents in the sport of their children. Delforge and Le Scanff (2006) point out constructive parental behaviours, while others, such as Nielsen (2010), Stroebel (2010) and Siekanska (2013), highlight undesirable parental behaviour, ranging from under- to over-involvement in the sport of their children.

This article reports qualitative research that addressed the following question: *what are the experiences of families with adolescent high achievers in sport?* The focus was on adolescent high achievers in track and field, as the findings of De Vos *et al*. (2011) suggest possible applicability to other sport codes.

METHODOLOGY

The research design was qualitative, exploratory, descriptive and contextual in nature, within an interpretive paradigm. The interpretive paradigm views the nature of reality as socially constructed and created by the persons involved in the situations (De Vos *et al*., 2011). Experiences of people create knowledge and are subjective in nature. A case-study approach (Yin, 2009; Polit & Beck, 2012) was followed, which is the intensive study of a single unit. In this research, a family was viewed as the unit under investigation. Phenomenological in- depth interviews, as recommended by Creswell (2013), were conducted with purposively selected participants to obtain an overview of their interpretation of their experiences.

Participants

In this study, 3 families with adolescent high achievers in sport were involved. During the interviews, the participants provided detailed descriptions of their experiences. Due to the extensive information gained from interviews, the many observations and the writing of field notes, the sample size in qualitative research is usually restricted (Ritchie & Lewis, 2003). Based on the recommendations of Brink *et al*. (2012), the researchers of the current study attempted to reach data saturation of information about the experiences of families with a sport achiever, rather than using a large sample.

A purposive sampling method was used. According to Ritchie and Lewis (2003), this refers to sample units that are chosen because they have particular experiences and knowledge that will enable researchers to obtain a detailed understanding of the phenomenon under investigation. In the case of this research, the sport code selected was track and field athletics.

The inclusion criteria required that athletes were to be between 13 and 18 years of age, who were able to express themselves in Afrikaans or English. The final criterion was one of the following: possible future Olympians; ranked among the top-50 in the world; was an African champion; was a South African champion; or ranked among the top-3 in South Africa. The final sample consisted of 3 adolescents (2 from track and 1 from field events), their parents and their siblings.

Data collection

In-depth interviews, as recommended by Glaser and Strauss (2009, cited in Gray, 2009), were conducted with purposively selected families who were willing to share their experiences. Interviews were conducted in the same manner with each family. Face-to-face interviews were conducted with the entire family, consisting of the parents, the high-achiever child and his or her siblings. Additional interviews were then conducted with the parents alone, and thereafter with the high achiever and his or her parents.

The interviews provided an opportunity for a detailed investigation of each person's personal perspective. Understanding of the personal context within which the research phenomenon is located is imperative. The interviews were audiotaped with a signed consent from the participants. The researcher visited the families repeatedly during the research period. Each interview lasted at least an hour. Data saturation was reached when statements made in previous interviews were repeated. In other words, interviewing was terminated when very little new information emerged.

The interviews were guided by the following central request: "Please tell me how you experience being part of a family with a high achiever in sport". Since expressing their feelings and issues related to the high achiever was an unusual experience, the researcher deliberately used empathy, intuition, patience and wisdom, as recommended by LoBiondo-Wood and Haber (2010). One of the researchers in the current study, experienced in family counselling and interviewing techniques, conducted the interviews.

Analysis of data

Tesch's method of thematic coding (Creswell, 2013) was used to analyse the transcribed interviews. The following steps were followed: read through each individual transcription to get a picture of the whole; jot down, in the margin, ideas and thoughts of the responses of

a particular interview as they come to mind; repeat the process with all transcribed interviews; list and cluster similar topics together in columns; convert topics into codes and themes. Once consensus was reached on the themes, member checking with all 3 families was done. Verbatim quotes from the interviews to illustrate the various lived experiences are presented as part of the findings.

The data were analysed further in a cross-validation to create one voice (Yin, 2009; Thomas, 2011). Cross-validation is the process of comparing the findings of different case studies. The phenomenon, a family with a high achiever in sport, was viewed from different perspectives in order to enhance the understanding thereof. After analysing the data, the research findings were compared with that in the literature (Creswell, 2012) to identify similarities and differences, as well as the uniqueness of the research findings.

The trustworthy model of Guba (De Vos *et al*., 2011) was used adhering to the 4 aspects proposed by Merriam (2009), namely truth-value, applicability, consistency and neutrality. Truth-value is obtained from the detection of human experiences as participants live and perceive them. The verbatim quotes of participants substantiate this. Member checking, as recommended by Niewenhuis and Smit (2012), was done by reading parts of the interview data to the relevant participants. Credibility was established when participants recognised the research findings as their own experiences. Audiotaped interviews, therefore, presented more reliable evidence than would hastily written field notes during the interviews. A protocol for analysis of the data was sent to an independent coder who was familiar with conducting qualitative data analysis. The interviewer and the experienced independent coder reached consensus with regard to the findings.

Ethical considerations

The Ethics Committee of University of Johannesburg granted ethical clearance (reference number 03/06/03). The parents gave informed written consent and the minors gave written assent. They were informed that they could withdraw their participation at any time and that all information would be anonymous and confidential. The researcher conducting the interviews explained that after personal disclosures during interviews, a counsellor would be available to provide emotional support should such a need arise.

RESULTS

Table 1 provides an outline of the sample and the interviews that were conducted. In 2 families, there were only 2 children, both adolescents. In the third family, the age difference between the first 2 of 3 children, who were both adolescents, was 3 years. There was also a toddler in the third family who did not participate in the interviews. One couple (husband and wife), as well as one other father-coach, were involved in the sport training of their own child. Two of the fathers coached their own children. According to Côté *et al*. (2005), any type of interview conducted with athletes concerning their experiences needs to consider not only what the researchers want to know, but also what the athletes are able to report accurately.

TABLE 1. **SAMPLE AND INTERVIEWS CONDUCTED**

Family	Sample	Interviews conducted

Family 1		1. F_1, M_1, A_1 & S_1
Parents	F_1 & M_1	2. F_1 & M_1
Children	A_1 [High achiever, elder sister]; S_1 [Younger sister]	3. F_1, M_1 & A_1
Family 2		1. F_2, M_2, A_2 & S_2
Parents	F_2 & M_2	2. F_2 & M_2
Children	A_2 [High achiever, elder brother]; S_2 [Younger sister]	3. F_2, M_2 & A_2
Family 3		1. F_3, M_3, A_3 & S_3
Parents	F_3 & M_3	2. F_3 & M_3
Children	A_3 [High achiever, elder sister]; S_3 [Younger sister] T_3 [Toddler not included in the interviews]	3. F_3, M_3 & A_3

F = Father M = Mother; High Achiever = A; S = Sister; T = Toddler

The findings from the interviews will now be discussed, with participants quoted verbatim. A literature control was used to corroborate the quotations. The most important categories will be discussed as part of each theme.

Family 1

When one of the children in a family is a high achiever in sport, the whole family is affected

There were 3 sub-themes, namely (1) the dramatic changes in lifestyle from the time when the parents were young, in terms of their perception of time, social life, illnesses and injuries;
(2) the sacrifices that families of high achievers have to make; and (3) the advantages that benefit the whole family through the achiever.

A high achiever in sport affected the whole family. The parents in this family hold forth that their children have more opportunities in sport than they had, as they grew up in the era of Apartheid during which international sport participation was boycotted.

> *…because of isolation, we could not compete overseas, it was not meant for us.* (F_1)

The high achiever did not view her family as a normal family. If she had to participate in athletic meetings, the whole family had to go to bed early.

> *When it comes to big athletic meetings, we all have to go to bed early, must be very quiet so that Ousus* (nickname of older sister who was the high achiever) *can rest. When it is cold, nobody can go out, because Ousus might catch a cold. Everybody eats what Ousus eats, because she has to perform* (F_1).

The mother found it impossible to take a weekend or day off to be just by herself.

> *So yes, to find a weekend or a day to take off, or whatever for you are almost impossible* (M_1).

Their marriage was also challenged, because of having a high achiever in the family. The parents did not have enough time to spend on their marriage.

Acceptance of the trying circumstances of being a high achiever in sport made it easier for him or her to cope

The high achiever accepted her circumstances.

> *I really love my sister; I don't want her to feel bad because I'm getting so much and I want to be a good example to her* (A_1).

She did not participate in sleepovers.

> *I never get to go to mass sleepovers, half way through the movies; my parents fetch me if it is late. I'm never allowed to travel by bus. I also need lots of friends; otherwise I'll die* (A_1).

As younger siblings ('the other child') grow older, they try to find their own niche in the family

As the younger sister grew older, she tried to find her own niche in the family. She knew that her parents loved her, but understood that her high achiever sister needed all the support of her parents.

> *I know my mom and dad love me. It's just that she has this big talent. She needs all their help* (S_1).

Before participating in the study, the high achiever never realised how her younger sister viewed her achievements.

> *I never realised how my sister looked at things. This was the first time our family talked like this. Yes, we talked a lot about athletics and goals, but not like this* (A_1).

It was only during the interviews that the family expressed their experiences of having a high achiever in their family. Previously they only discussed athletics and goals that the high achiever should reach.

Coaches become just as important to the high achiever children as their own parents do

The high achiever viewed her coach as a second mother, "She is like a second mother to me". (A_1)

Family 2

When one of the children in a family is a high achiever in sport, the whole family is affected

The same 3 sub-themes identified in Family 1 were also identified in Family 2, namely (1) the dramatic changes in lifestyle from the time when the parents were young, in terms of their perception of time, social life, illnesses and injuries; (2) the sacrifices that families of high achievers had to make; and (3) the advantages that benefit the whole family through the achiever.

The family spoke about the effect the high achiever had on the family. The parents voiced that they could not compete overseas as a result of growing up in the Apartheid boycott years.

…because of isolation, we could not compete overseas, it was not meant for us.

(F_2) Nowadays children have more opportunities to compete in sport.

The high achiever also did not view his family as normal with the phrase "…if we were a normal family" (A_2). One of his parents also said: "… you try and let them lead a normal child's life" (F_2). A_2 focused on the future. He wanted to participate in the Olympic Games and break the Olympic record.

I want to win the Olympic Games in 2012. I am going to break the Olympic record. (A_2)

The parents expressed that sport also occupied their time during the week:

During the week, we are busy with sport. When we get home we are tired and don't want other people around you. Sundays we go to church, but although it would be nice if someone invited us to lunch, no one ever does. So, Sundays we also spend alone. We only have three or four real friends. (M_2)

When it came to 'health and injuries', the father went into denial by saying:

…definitely don't think it will happen. There is no way. When the money runs out at the end of the month, I'll go and buy vitamins for the children before I buy a beer. (F_2)

The parents admitted that their marriage was challenged since they did not have time to spend in each other's company. They expressed the importance of teamwork in their family; the parents needed to support each other:

So if my Mum finds it difficult, my Dad's right there. They're used to working as a team. (A_2)

Acceptance of the trying circumstances of being a high achiever in sport made it easier for him or her to cope

The high achiever had many friends who were also athletes.

I have many friends; they are also runners, but they can't come to my house and ride horse, the parents are scared they might get hurt and then can't run. (A_2)

The high achiever did not regard schoolwork as a priority:

I'm already getting 75/80%, but I miss a lot of schoolwork due to competitions. My teachers do not always understand. Academics are last on my list of priorities. (A_2)

As younger siblings ('the other child') grow older, they try to find their own niche in the family

The high achiever's younger sister said:

When I was younger, it used to bug me when my brother (the high achiever) *didn't want to come and watch me, but now I understand why, he was always training or competing. So, it doesn't bug me anymore. I love him. It will be lonely without him when he leaves for America to run.* (S_2)

Coaches become just as important to high achiever children as their own parents do

The father decided to coach his own high achiever son: The high achiever son did not want to disappoint his father by not achieving in sport:

I told my child when I wear this cap, I'm Dad, when I wear that cap, I'm coach. (F_2)

The worst thing for me is to disappoint my Dad in my sport. (A_2)

Family 3

When one of the children in a family is a high achiever in sport, the whole family is affected

Two of the sub-themes identified in Family 1 and Family 2 were also identified in Family 3, namely (1) the dramatic changes in lifestyle from the time when the parents were young, in terms of their perception of time, social life, illnesses and injuries; and (2) the sacrifices that families of high achievers had to make.

The mother reminisced:

When I was 19, I was almost married. That's what you did in those days. My child is getting out into a big wide world, wider than we are used to. (M_3)

The mother expressed that the family did not have real friends and that other people criticised them a lot. Their peers did not really accept these parents, since the parents did not have time for socialising:

They do not really accept you. They regard you as too important for them, that you are stuck-up when you do not want to visit them. They criticise you a lot. (M_3)

Other people perceived these parents not wanting to socialise with other people. The father found it tough to support the high achiever daughter financially:

…but also the visits to doctors, physiotherapists, chiropractors and homeopaths. Within three months, the medical aid funds meant for a year can be easily depleted. (F_3)

The mother expressed that she and her husband had no time to spend together, which was quite challenging for their marriage:

There is no time for us … the last few years our marriage was not good. (M_3)

Acceptance of the trying circumstances of being a high achiever in sport made it easier for him or her to cope

The high achiever daughter planned to study business management in the future, but her

current focus was on her sport achievement, "But not now". (A_3)

As the younger siblings ('the other child') grow older, they try to find their own niche in the family

The high achiever's younger adolescent sister realised that her high achiever sister's participation in sport also benefited her:

> *So I don't mind so much anymore that my sister is getting so much attention. I get to travel with her sometimes.* (S_3)

Coaches become just as important to high achiever children as their own parents do

To find the right coach was very difficult. However, the parents did find the right coach for their high achiever daughter.

> *Very difficult. Not that they are too few, they might just not suit your child.* (F_3)
> *Our coach is like a father to us. He is very committed. He makes us part of his life.* (A_3)

DISCUSSION

The three families repeated four themes regarding their experiences of having high achiever children in sport, namely (1) when one of the children in a family is a high achiever in sport, the whole family is affected; (2) acceptance of the trying circumstances of being a high achiever in sport made it easier for the achievers to cope; (3) as younger siblings grow older they try to find their own niche in the family; and (4) coaches become just as important to high achiever children as their own parents.

1. *When one of the children in a family is a high achiever in sport, the whole family is affected.*

The lifestyles and experiences of the high achievers differed greatly from those of their parents when they were young. The mother from Family 3 stated that she was almost married at 19, since that was what you did in those days. Her child was stepping out into a big, wide world that is more inclusive than what they, as parents, were accustomed to. The parents of all three families were of the opinion that their children had more opportunities than they had when growing up in the Apartheid era, due to sport boycotts against South Africa.

The era in which the children of today are growing up, as well as the functioning of the families in this era, differs significantly from the society of 20 and more years ago. What parents remember as daily news, their children perceive as ancient history, because so much has changed (Elmore, 2001). The words 'apartheid' and 'isolation' are foreign to them. The Apartheid regime barred people of colour from participation. At present, the quota/targets in South African sport focus on developing black sport men and women (SABC Sports News, 2014).

The high achiever children of all three families thought that their families were not normal since they focused so much on the high achievers and their sport. Grisgono (1991) and Siekanska (2013) agree that the demands of a sport can be detrimental to normal family life.

Children, who participate in competitive sport, and especially high achievers, are very time-conscious. This refers to present time management of daily activities, but also to future directedness. According to Ben-Baruch *et al*. (1991) and Poggenpoel and Myburgh (2002), time is inseparably associated with achievement and success. For the high achievers, time is also clearly directed to the future, as mentioned by A_2 who said that he wanted to win the Olympic Games in 2012. In fact, he intended to break the Olympic record.

Although people always surrounded the interviewed families, their social lives were also greatly affected. M_1, F_2 and M_2 described how their high achiever children's sport kept them busy during the week. They lived isolated lives with very few or no friends. Social isolation can be serious. Goleman (1997) ascribes it to the sense that you have no one to share private feelings or with whom you have any close contact. All six parents were also criticised for their focus on their high achiever children's sport and for not making time for other people. Concerning health and injuries, F_2 did not think that his high achiever son would ever suffer from injuries. Nonetheless, dealing with injuries and failures is actually one of the true challenges of participating in sport (Rotella & Bunker, 1987). According to Smoll and Smith (2012), the responsibility to recognise and manage sport-related injuries often falls on the parents and they should be knowledgeable about their nature and treatment.

The second sub-theme was about the sacrifices that high achievers' families had to make and how it affected each family member. Family members mentioned how it affected their diet and rest, finances, travelling, teamwork, marriages and own dreams. F_1 explained that before big athletic meetings, the whole family had to go to bed early and be very quiet so that the high achiever could rest. Nobody in the family could go out in cold weather because the high achiever might catch a cold. Everybody in the family ate what the high achiever ate because she had to perform well. This was quite significant. In 'normal families', the children go to bed early when the parents say so. In families with a high achiever, the parents go to bed early because the children's lifestyle demands it. Brown (2001) warns that if the athletes stop participating in athletics because of any reason, it is imperative that both parents and athletes have developed an identity that is not dependant on athletic achievement.

The families also had to make financial sacrifices. A number of the parents expressed that they find it hard to support their high achiever children financially. F_2 stated that if they would run out of money at the end of a month, he would buy vitamins for the children before buying a beer. F_3 indicated that trips to various competitions, as well as visits to doctors, physiotherapists, chiropractors and homeopaths, depleted a year's medical aid funds very quickly. Parents and coaches should, therefore, consider the cost realistically, whether they can afford it or not, before deciding that the athlete is going to become a sport star (Brown, 2001). Côté (1999), however, found that, somehow, families find the required financial resources by sacrificing their own needs and wants.

Travelling poses another big challenge, since South African adolescents cannot have a driver's licence, and the public transport in South Africa is poor. Travelling to training sessions, competitions, racing from one city to another and trying to accommodate each child's schedule proved to be a mission. The mothers especially seem to be sacrificing their own dreams and desires to support their high achiever children. Coakley and Donnelly (1999:119) note that someone once wrote, "If a mother's place is at home, why am I always

in the car?" M_1 stated that it was almost impossible for her to take a weekend or a day off.

All the sacrifices that the parents had to make seemed to have taken a toll on their marriages. For some couples, youth sport become a deceptive blessing by way of which they avoid dealing with marital discord, since their life focus becomes their child in the athletic arena (Smoll & Smith, 2012). M_1 and M_3 expressed that they had no time to spend on their marriages, which challenged their marital relationships. High achievers, like any other

teenager, are affected by the impaired marital relationships of their parents. Divorce, separation or on-going parental conflict undermines the security of an adolescent's love (Narramore & Lewis, 1990). In all three families, teamwork seemed to be the keyword. A_2 explained that when his mother found the focus on his sport challenging, his father would be there to support her. Malina (1994) points out that top performance demands planning and a consistent self-organisation that children cannot manage by themselves. The high achiever should have a developmental team leader who monitors the athlete's developmental needs on a daily basis. It could be a parent, coach or friend (Saviano, 2000 cited in Brown, 2001).

Nevertheless, sport at this high level also brought many advantages not only to the high achievers, but also to their families. S_3 said that she no longer minded that her high achiever sister received all the attention, as she got to travel with her to far-away exciting places, appearing in the media and receiving sponsorships. It is not unusual for an entire family to relocate to take advantage of better training and lifestyle opportunities (Sloane, 1985 cited in Dosil, 2006).

2. *Acceptance of the trying circumstances of being a high achiever in sport made it easier for him or her to cope.*

It was evident throughout the present study that the parents' support played a crucial role in all three families. One thing that talented people tend to share is an enriched home life with enthusiastic and appreciative parents (Lansdown & Walker, 1992).

All three high achievers indicated that they cared about their siblings ('the other child') and did not want them to suffer because of their achievements. A_1 expressed that she really loved her sister and did not want her to feel bad because she (the high achiever older sister), received so much of everything. She wanted to be a good example to her younger sister. However, sometimes there were power struggles between spouses, siblings and high achievers and parents. This is in line with description of Dinkmeyer and McKay (1982), regarding the effect of power struggles in families.

Apart from the many advantages and rewards, high achievers also pay a high price with regard to friends and schoolwork. They have a very limited social life. During the week, they go to school and they train every afternoon. They have limited time for homework. Then they are off to bed. They do not visit anybody during the week and nobody visits them. If there are no competitions the next day, the parents tend to be more lenient on Friday nights. It is, however, important for a high achiever to develop social relationships outside of the athletic group. Sport should not be the only leisure activity (Grupe, 1979 cited in Malina, 1984).

Although parents emphasised both school and sport achievements, schoolwork took second place. A_2 mentioned that he achieved 75% to 80%, but that he missed a lot of schoolwork due to competitions, and that his teachers did not always understand. Schoolwork was last on his list of priorities. Athletes should try to balance their schoolwork and sport (Grupe, 1979 cited in Malina, 1984). Intellectual and cognitive development should not be permanently impaired by top-level sport, since it is very important for their future. The three high achievers in the study realised that they needed a career for life after athletics. One wanted to become an

electrical engineer, one a sport psychologist and the other wanted to study business management, but only after she had completed her sport career.

3. *As younger siblings ('the other child') grow older, they try to find their own niche in the family.*

It was difficult to find specific data other than general remarks on possible rivalry in the existing literature. 'The other child' in the family prominently experienced feelings of initial rejection, jealousy and resentment, which made the parents feel very guilty. However, as the other children grew older, feelings of acceptance started emerging. S_1 said that she knew that her mother and father loved her. She understood that her older high achiever sister was very talented and needed all her parents' assistance.

All the children in all three families seemed to love each other a lot, but they have not communicated these deep feelings or dealt with them as yet. A_1 confirmed this when she said that she never realised how her sister ('the other child') looked at things. It was the first time that their family shared their experiences so openly. They often talked about athletics and goals, but not about their feelings and experiences. The statement of A_1 confirmed the need for in-depth research into how individual family members experience this complex phenomenon, because of the diversity of family contexts and the needs of individuals in the family. This is in line with Côté (1999), who previously highlighted this need for research about experiences of families with children who are high achievers in sport.

4. *Coaches become just as important to high achiever children as their own parents do.*

Two of the fathers coached their own children. The other father had to find the right coach. F_3 stated that it was very difficult to find the right coach for his high achiever oldest daughter since a possible coach might just not suit his high achiever child. A_3 said that her coach was like a father to her. He was very committed and made his athletes part of his life. A_1 said that her female coach for one of her disciplines was like a second mother to her (A_3). The interrelationship between the coach and the child, the coach and the parent, and the parent and the child are important components for successful sporting experiences, since the child is part of his or her family, not that of the coach.

Significant in this study was that where the fathers were the coaches, the athletes saw the father and coach as one. The fathers, however, could separate their roles. While the influence of a coach can be great (Grisogono, 1991), it is magnified if the coach also happens to be a child's parent. F_2 told his child when he wore one cap he was Dad and when he wore another he was coach. This, however, did not make sense to A_2, who said that the

worst thing for him would be to disappoint his father in his sport.

Smoll (1993, cited in Brown, 2001) emphasises that there has to be an understanding between the parent and the child that parenting behaviour and coaching behaviour will be different, and the parent-coach must understand the child's perspective on the situation. The parents in all three families adapted to a new lifestyle that centred on the activities of the high achiever, often placing their own needs and those of the other family members last. The focus shifted from a family system where parents plan, structure and manage family life and activities, to a

family where the needs and challenges of the adolescent high achiever takes centre stage. This is in line with the research findings of Siekanska (2013). The other family members thus moved to the periphery. Where the father was also the coach, he became part of the centre, yet still not the centre.

Sacks *et al*. (2006) refer to this finding as the 'athletic family' as opposed to the 'family with an athlete', in the same manner as distinguishing an 'alcoholic family' as opposed to a 'family with an alcoholic'. In the first scenario, the concept of family influence is incorporated in a reality in which the athlete is the centre of the system and his or her goals become the system's goals. In the latter scenario, the family may nurture the sportsperson and have some level of influence, but the athlete acts more or less as an independent agent.

CONCLUSIONS AND PRACTICAL APPLICATION

The aim of this article was to explore and describe the experiences of families with a high achiever child in sport. The data were too extensive to report on in one article. Therefore, particular evidence of the findings was presented in an attempt to evade the loss of meaning and compromising the aim of the study. Previous studies mostly reported on the supporting role of the parents in young children's involvement in sport. Few authors attempted to study the complete family dynamics. The research revealed, among other phenomena, that a high achiever in sport determines the family's experiences.

The study showed that families with high achiever children are sport-involved families trying to live a balanced life. Their children tend to be more focussed, disciplined and future- directed than most other adolescents and even some adults. Not only the children, but also the parents, need social support systems. Although the families are constantly talking to each other, their interpersonal relationships and communication skills need to be developed further. In addition, the findings showed a great deal of caring, concern, moral support and positive expectations for the future. Siekanska (2013) showed that the participation of adolescents in sport develop certain positive aspects of their being, if their parents care about them. The current study confirmed this finding. Even 'the other children', who did not always find their niche in sport, were able to cope with the environment in which they lived.

It is clear from the results that the focus of the parents is on the high achiever child, while the other siblings tend to be left behind. The marital relationship of the parents is also challenged. These families should master the skills of mindfulness and practise mindfulness in their everyday life. The skills of mindfulness include awareness, perception of experiences in a non-judgemental way and not labelling experiences, living in the present

moment and accepting that they can choose how to respond to behaviour, as well as being open to possibilities and seeing their own experiences as an opportunity to learn and grow (Tull, 2009; Duke Health Organisation, 2010).

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EMG ANALYSIS AND MODELLING OF FLAT BENCH PRESS USING ARTIFICIAL NEURAL NETWORKS

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ABSTRACT

The objective of this study was to evaluate the contribution of particular muscle groups during the Flat Bench Press (FBP) with different external loads. Additionally, the authors attempted to determine whether regression models or Artificial Neural Networks (ANNs) can predict FBP results more precisely and whether they can optimise the training process. A total of 61 strength-trained athletes performed four single repetitions with 70, 80, 90 and 100% of one repetition maximum (1RM). Based on both kinematic and electromyography results, a regression model and ANNs for predicting the FBP performance was created. In an additional study, 15 athletes performed the training session in order to verify the created model. The results of the investigation show that the created neural models 9-4-1 structure (NRMSE [Normalised Root Mean Squared Error], for the learning series was 0.114, and for the validation and test series 0.133 and 0.118, respectively), offer a much higher quality of prediction than a non-linear regression model (Absolute regression error – Absolute network error =47kg–17kg=30kg).

Key words: Non-linear models; Artificial neural networks; Bench press performance; Electromyography.

INTRODUCTION

The Flat Bench Press (FBP) is one of the most popular strength exercises performed by athletes of different sport disciplines (Van den Tillaar & Ettema, 2009). FBP performance is significantly influenced by the strength and power of several muscle groups and by proper technical execution of the movement (Lehman, 2006). A successful bench press lift is performed when the barbell is first lowered (descending phase) to the chest and then moved to a fully extended position (ascending phase). The recognised primal movers for FBP include the *Pectoralis major* (PM), *Triceps brachii* (TB) and *Anterior Deltoid* (AD), but the performance itself is strongly influence by their antagonists and synergists, such as the *Pectoralis minor*, shoulder external rotators or *Latissimus dorsi* (LD). Understanding the

relative contributions of different muscles and the kinematic changes across movement phases with increasing load can help to characterise the benefits and risks of the exercise, and can also improve training effectiveness.

Prediction of one repetition maximum (1RM) by 10RM itself has been studied for the purpose of setting accurate training intensity in the early stage of a training session (Brzycki, 1993; LeSuer *et al*., 1997; Reynolds *et al*., 2006). Many prediction equations take into consideration only the sport results, so in effect the conclusions are in high inaccuracy regarding to different motor tasks (Hoeger *et al*., 1987; LeSuer *et al*., 1997). Current development of technology enables researchers to measure 3D kinematics and muscle activity along with different exercise intensities. By the recognition of Hills curve, there are three parameters, which influence muscle strength production: length of muscle, muscle excitation and speed of contraction (Siff, 2003). The kinematics variables are described by movement acceleration, while the bioelectrical activity can describe the level of muscle excitation. The FBP during 1RM is recognised in importance of electromyography (EMG) mean amplitude for PM, AD and LD (Santana *et al*., 2007), but their study did not refer to the activity of the TB. In the study of Van Den Tillaar and Ettema (2009), FBP showed the same pattern of muscle activity, yet there were differences in kinematics. Thus, the 1RM flat bench press performance model should be described in a more complex form and by innovative methods.

The prediction of exercise performance is complex and dependent on the modelling of frequently non-linear interactions (Zehr, 2005; Van Den Tillaar & Ettema, 2009). Non-linear tools (non-linear regression and neural models), are available to describe such phenomena. However, there is no agreement over the relative accuracy of such methods in predicting results (Maier *et al*., 2000; Zehr, 2005; Maszczyk *et al*., 2012). It is hypothesised that neural network modelling will better identify the potential of athletes in the FBP, compared to a typical regression model (Jolivet *et al*., 2008; Rahmani *et al*., 2009; Trebs *et al*., 2010; Maszczyk *et al*., 2011).

Neural networks can be employed wherever a relationship between explanatory variables (inputs) and explained variables (outputs) exists (Gregor & Pink, 1985; Haykin, 1994). However, they are especially useful for seeking very complex input-output relationships, which are difficult to capture using statistical methods that are usually applied in such cases

(for example, the analysis of relationships or the separation of taxonomically homogenous groups). Considering that the relationships between variables may be either linear or non-linear, recently Artificial Neural Networks (ANNs) have been used more frequently to identify their actual nature (Lees, 2002; Bartlett, 2006; Maszczyk *et al*., 2011). At present, this tool is used frequently for solving modelling and prediction issues (Maier *et al*., 2000; Lees, 2002; Zadeh, 2002; Bartlett, 2006; Maszczyk *et al*., 2012).

PURPOSE OF STUDY

There were two objectives of this study: to determine the differences in EMG amplitude due to increased exercise intensity (70, 80, 90 and 100% of 1RM); and to create an ANNs prediction model for 1RM FBP performance and to determine the accuracy between ANNs prediction and typical regression prediction. Therefore, this study had two distinct phases of investigation. During the first one, the main objective was to determine the EMG activity of

particular muscle groups during the FBP with different external loads. The second was intended to determine whether regression models or ANNs predict sport results more precisely and was the primary goal of this investigation.

METHODOLOGY

Participants

The study group consisted of 61 strength trained sportsmen (aged 23±2yrs, body mass 79.2±3.6kg; body height 180.2±4.0cm; 1RM bench press: 90±12.4kg), from the MAX FIT CLUB POLAND. The participants (N=36) were selected randomly (from 75 sportsmen) for the construction group (CG) for the construction of the first model and 15 subjects were chosen for the new training cases group (NTC), in order to construct the model. Then, 10 participants were selected (whose results were not built into the models), to be included as a test group (TG) for the second session (verification of models prediction).

The core investigation was preceded by 3 months of general and specific physical fitness training in own clubs and in the Academy of Physical Education in Katowice (APEK) facilities. Each sportsman participated in 3 training sessions per week in his own sport club and 3 additional training sessions per week in the APEK facilities, for the purpose of this research. Written informed consent was obtained from all participants. The subjects were free from any upper limb injury, and had no cardiovascular or metabolic diseases as reported in a health questionnaire. Subjects with upper limb injury or previous surgery were excluded from the research group. The Bio-ethics Committee for Scientific Research at the Academy of Physical Education in Katowice approved the project.

Test protocol

After a general warm-up performed with recommendations of the American Society of Exercise Physiology (Brown & Weir, 2003), each subject performed a specific warm-up that consisted of 2 sets of 6 repetitions of the FBP with a load of 60% 1RM. The test protocol included 4 sets of 1 repetition of the FBP with 70, 80, 90 and 100% of 1RM. The

participants performed a traditional bench press (descending and ascending the barbell). No marked pause between descending and ascending the barbell was necessary. However, the participants were not permitted to 'bounce' the barbell off the chest and were not allowed to raise the lower back from the bench.

3D Kinematics and electromyography

Multidimensional movement analysis was made with the Smart-E measuring system (BTS, Italy), which consisted of 6 infrared cameras (120Hz) and a wireless module to measure muscle bioelectric activity (Pocket EMG 1kHz, pass band 10-500Hz, 16 channels). Modelling in 3D space, as well as calculations of parameters was performed with the help of Smart software (Smart Capture, Smart Tracker and Smart Analyser, BTS, Italy). The set of passive markers permissive on delimitation of chosen parameters of the barbell and the participant was applied. Technical accuracy of the system after the calibration process

equalled 0.4mm (the distance between 2 markers in 3D). The motion of the bar in every repetition was divided into 2 phases: descent ($_D$) and ascent ($_A$) ones.

TABLE 1. **STANDARDISED VARIABLES USED TO CONSTRUCT MODELS**

Variables	Mean	SD	CV
Y1(FBP)	0.708	0.851	-0.755
PMD	-0.358	-0.432	-0.381
PMA	-0.357	-0.432	-0.515
PMsum	-0.352	-0.422	-0.540
ADD	-0.359	-0.431	-0.195
ADA	-0.357	-0.428	-0.301
ADsum	-0.352	-0.418	-0.354
TBD	-0.362	-0.438	-0.023
TBA	-0.360	-0.433	-0.306
TBsum	-0.357	-0.429	-0.339
LDD	-0.364	-0.442	-0.027
LDA	-0.363	-0.441	-0.184
LDsum	-0.363	-0.440	-0.208
XD	-0.174	0.138	0.079
XA	-0.168	0.285	0.375
YD	3.556	3.373	-0.860
YA	3.773	2.950	-0.929
ZD	0.817	1.507	-0.554
ZA	0.760	2.015	-0.312
VmeanD	-0.361	-0.439	-0.509
VmaxD	-0.359	-0.435	-0.515
VminD	-0.364	-0.442	1.433

VmeanA	-0.361	-0.438	-0.414
VmaxA	-0.359	-0.435	-0.479
VminA	-0.364	-0.441	3.509
AmeanD	-0.357	-0.424	-0.080
AmaxD	-0.335	-0.383	-0.359
AminD	-0.364	-0.440	2.490
AmeanA	-0.355	-0.419	-0.006
AmaxA	-0.330	-0.385	-0.520
AminA	-0.364	-0.441	2.421
TD	-0.347	-0.414	-0.512
TA	-0.347	-0.399	-0.128

SD= Standard Deviation CV= Coefficient of Variances

Considering the data describing the kinematics of the bar, the following variables were calculated to define a quantitative motion of the bar. Before the 1-RM experimental test, the skin was prepared (shaved, washed with alcohol, abraded), for the placement of gel coated surface EMG electrodes. Electrodes (11mm contact diameter) were placed on the dominant side of the body on the belly of the muscle in the presumed direction of the underlying muscle fibres with a centre-to-centre distance of 2.0cm according to the recommendations by SENIAM (Hermens *et al*., 2000).

PM electrodes were positioned halfway between the sternal notch and anterior auxiliary line. AD electrodes were placed 2 finger-breadths below the acromio-clavicular joint and angled towards the deltoid tuberosity. The electrodes for the TB were positioned mid-way between the acromion and olecranon processes on the posterior portion of the upper arm on the long head of the triceps. LD electrodes were placed in the middle part of the muscle, at the height of spinous process of the first lumbar vertebra. A ground electrode was placed directly over the right anterior-superior iliac spine. This method of electrode placement was similar to that of Cram and Kasman (1998). The normalisation procedure (MVIC) was carried out in accordance with the recommendations by SENIAM (Hermens *et al*., 2000; Konrad, 2005).

In order to test the hypothesis, multidimensional statistical analyses were applied to measurements taken in the construction group (CG). The research problem was addressed by using an empirical and predictive investigation, based on the data obtained in the form of a multidimensional vector of variables, including independent X_n variables and 1 dependent variable Y-bench press results (1RM). Based on the results of the 51 participants, mathematical models were created. Then, an additional study was conducted on a group of 15 participants, in order to verify previously created models.

Numerous characteristics of the participants were measured and served as the independent variables, and included specific variables of the bench press (Table 1). The dependent variables included the results of the bench press. During the measurements, 32 variables were identified. To determine the optimal set of predictors, the R0 vector was determined for the explanatory variables and the R1 vector for the correlations generated by the R0 vector for variables showing a significant correlation with the explained variable Y1 – FBP

result.

This approach allowed determining 13 predictors, which significantly improved the models explained by variable Y1 (the result of the FBP). The mean values of this variable were used in the multiple regression models. However, 4 variables were removed from the model following statistical testing (testing the significance of the hypothesis and statistical verification of structural parameters of regression equation for dependent variable Y1- within the meaning of the equation: sign ($r(x_j,y)$)=sign (a_j).

Ultimately, the regression equation was re-estimated with the remaining 9 explanatory (statistically significant) variables:

$Vmax_D$= Maximal velocity during the descending phase (B=1.3)
$Amin_A$ = Minimal acceleration during the ascending phase (Beta=0.6)
Z_A = Anterior-posterior displacement during the ascending phase (Beta=0.5)
$Amax_A$ = Maximal acceleration during the ascending phase (Beta=0.8)

$Vmin_A$ = Minimal velocity during the descending phase (Beta=0.3)
TB_A = *Triceps brachii* during the ascending phase (Beta=0.4)
X_A = Lateral displacement during the ascending phase (Beta=0.4) Y_A = Vertical displacement during the ascending phase (Beta=0.6) T_D = Time of the descending phase (Beta=0.7)

Modelling procedure

The data of the CG were entered into the neural net and regression models were obtained from the measurements using the Smart-E system (BTS), which identified 32 independent variables. The data set was subdivided into 3 series: learning series (24 cases); validation series (6 cases); and test series (6 cases). Then, to enhance the model, 15 new training cases were added and estimated again (33 cases: learning series; 9 cases: validation series; 9 cases: test series). Regression and the neural net models confirmed the predictors for the TG, who was of the same age and had the same training experience as the CG, and whose results were not used to construct the models. So, the results of the predictions for the TG were verified by comparing the model-generated predictions with the actual results achieved by the same group 3 months later.

Statistical analysis

The EMG and kinematic parameter results of the first session were expressed as group means and standard deviations were calculated for all the variables. The Kolmogorov-Smirnov test of normality and Levene's test of homogeneity of variance were performed to verify the normality of the distribution. The 1-way ANOVA was applied to determine the statistical differences in EMG amplitude due to increased exercise intensity (70, 80, 90 and 100% of 1RM).

Regression and neural network models

Multiple stepwise regressions were used to select the explanatory variables offering the best

prediction of results in the CG. These 9 predictor variables were log-transformed and used to form regression models predicting Y (results of the FBP).

More formally, in a non-linear model, at least 1 derivative with respect to a parameter should involve that parameter. In this study, the $Y_1(t)=\exp(a_1t + b_1t^2)$ non-linear regression model was used and verified after being transformed to linear models using the transformation $X_{n1}(t)=\ln Y_1(t)$. For generalisation and prediction of sport results, Multilayer Perceptron (MLP) neural models were used to describe the bench press with the following structures: 9- 2-1, 9-3-1 and 9-4-1. In the Neural Network Statistica Module (NNSM), 100 epochs is the standard procedure, followed by 30 epochs of optimisation (Szaleniec *et al*., 2006, 2008). The networks were trained using the Levenberg-Marquardt algorithm. The level of significance for all analyses was set at $p\leq0.05$.

Testing data verifying model-generated predictions

The primary goal of the investigation was to compare and assess the predictive abilities of the non-linear regression and neural models. This necessitated testing the prediction values against the actual FBP results. After data collection, regression and neural models were built

and a second phase of research was conducted. One month after the beginning of the investigation, 15 participants performed the same training protocol as the first sample, and once again, independent variables were measured. FBP results were predicted using the above regression and neural models for the TG (n=10). Three months after the prediction of the bench press using these models, their results were recorded (true values). Model-generated predictions were compared to actual results (kg), and absolute errors were calculated. The calculation of absolute errors was dictated by the specificity of the regression models.

The regression function is built upon the method of least squares in which the sum of the squares in the numerator of the function must approximate as closely as possible that of the denominator. This creates a situation in which the model predicts results with great deviation, yet after adding up the deviations, the error will be close to zero. Thus, the model does not possess highly specific predictive possibilities. Only after adding up the values of absolute deviations in the neural and regression models can the superiority of non-linear neural models be detected, in which the absolute error is much smaller than in the regression models (Table 1). All statistical analyses in both groups of sportsmen were carried out on a PC using the statistical package *STATISTICA 9.1, STATISTICA* Neural Networks Module (Release 9) and *Excel 2010* from Microsoft Office 2010.

RESULTS

Numerous characteristics of the participants were measured, which served as independent variables and included specific variables of bench press (Table 1). All variables were normally distributed as suggested by the Kolmogorov-Smirnov test results. One-way ANOVA revealed statistically significant differences in EMG amplitude for the variables due to increased exercise intensity between 70 and 100% only:

Pectoralis major EMG amplitude (MVIC) during descending phase (PM_D);

Anterior deltoid EMG amplitude (MVIC) during descending phase (AD_D);
Anterior deltoid EMG amplitude (MVIC) during ascending phase (AD_A);
Triceps brachii EMG amplitude (MVIC) during descending phase (TB_D);
Triceps brachii EMG amplitude (MVIC) during ascending phase (TB_A);
Latissimus dorsi EMG amplitude (MVIC) during descending phase (LD_D); and
Latissimus dorsi EMG amplitude (MVIC) during ascending phase (LD_A).

TABLE 2. **ONE-WAY ANOVA IN EMG ACTIVITY OF MUSCLES AMPLITUDE BETWEEN 70% AND 100% 1-RM**

Variables	F	p
PM_D	6.588	0.014
AD_D	4.501	0.040
AD_A	5.737	0.021
TB_D	23.114	0.001
TB_A	34.117	0.001
LD_D	14.382	0.005
LD_P	23.216	0.001

The results of 1-way ANOVA suggested that if 1 or more muscles will be determined by a matrix for models, one could optimise their function for the best sport results (Y1-FBP). Table 2 shows the results of the 1-way ANOVA, which revealed a statistically significant difference in EMG amplitude due to increased exercise intensity between 70 and 100% only.

The regression model for the FBP results had the following form:

$$Y1(FBP) = 281.8 - 209.4*Vmax_D + 780.5\ Amin_A + 0.3*Z_A - 25.2*Amax_A - 267.2*Vmin_A - 112.7*TB_A - 1.4*X_A + 0.2*Y_A - 32.3*T_D$$

where:

Y1 = 1RM FBP result (kg)

$Vmax_D$ = Maximum velocity during descending phase (m/s) $Amin_A$ = Minimal acceleration during ascending phase (m/s^2)

Z_A = Anterior-posterior displacement during the ascending phase $Amax_A$ = Maximal acceleration during ascending phase (m/s^2) $Vmin_A$ = Minimal velocity during ascending phase (m/s)

TB_A = *Triceps brachii* EMG amplitude (MVIC) during ascending phase X_A = Lateral displacement during the ascending phase (mm)

Y_A = Vertical displacement during the ascending phase (mm) T_D = Total time of the descending phase (%)

Using the same variables of the perceptron models (Multilayer Perceptron: MLP) were constructed with the following structures: 9-2-1 (Normalised Root Mean Squared Error/NRMSE: learning data=0.478; testing data=0.488; validation data=0.476) and 9-3-1 (NRMSE: learning data=0.363; testing data=0.321; validation data=0.355). For networks 9-2- 1 and 9-3-1, values of NRMSE for validation series were not satisfactory. Finally, the use of architecture 9-4-1 brought a breakthrough. For the group of 36 sportsmen, the quality measures for this network were 0.228 for the training subset, 0.284 for the validation subset and 0.278 for the test subset.

However, with the 15 new training cases added to the model and following model re-estimation, the results improved. With regard to the new 9-4-1 networks, the NRMSE for the learning series was 0.114 and for the validation and test series 0.133 and 0.118, respectively. Thus, the practical usefulness of this model was supported by correlation coefficients of a large magnitude between independent and dependent variables in each group.

Table 3 includes the results of the verification procedure by which the prediction values generated by the non-linear neural networks and non-linear regression models for the sportsmen (n=10, the new group of the same age and the same training experience as the CG, and whose results were not used to build the models), in the FBP were compared with the actual results for the tested sportsmen.

TABLE 3. **TRUE AND CALCULATED VALUES FOR Y1 VARIABLE OF FBP 1RM**

		MLP 9-4-1			**Regression model**		
Athlete	True values [kg]	Calculated network value [kg]	Network error [kg]	Absolute network error [kg]	Calculated regression value [kg]	Regression error [kg]	Absolute regression error [kg]
1	85.00	90.00	-5.0	5.0	100.50	-10.5	10.5
2	90.00	90.50	0.5	0.5	87.50	5.0	5.0
3	92.50	92.00	1.0	1.0	97.00	5.5	5.5

4	102.50	101.50	-2.5	2.5	91.00	-3.5	3.5
5	87.50	90.00	-0.5	0.5	97.00	-2.0	2.0
6	95.00	95.50	-2.5	2.5	103.50	-3.5	3.5
7	100.00	102.50	-2.0	2.0	88.50	-3.5	3.5
8	85.00	87.00	-1.0	1.0	108.50	-3.5	3.5
9	105.00	106.00	-1.5	1.5	95.00	-5.0	5.0
10	90.00	91.50	-0.5	0.5	85.00	5.0	5.0
		Sum:	**-14.0**	**17***	**Sum:**	**-16.0**	**47***

DISCUSSION AND CONCLUSIONS

The main objective of the research was to identify the efficiency and predictive usefulness of artificial neural networks treated as a sportsperson's tool for optimising training in contrast to the widely used regression models. In order to accomplish the intended goals, an attempt was made to define which variables were most informative and qualified best to play the role of explanatory variables of the model.

The regression model identified the following predictors of sport results (Y1-FBP) as the most important: maximal velocity of the bar during the descending phase; maximal acceleration of the bar during the ascending phase; time of the descending phase; and vertical displacement during the ascending phase. The results of the analysis are in accordance with the conclusions of Requena *et al*. (2005) and Reynolds *et al*. (2006). Moreover, Van den Tillaar and Ettema (2009) also confirm that the maximum velocity during the descending phase (V_{maxD}), and lateral displacement during the ascending phase (X_a), is one of the most important parameters determining sport results - Y1-FBP. Unfortunately, there is little data about the application of regression and discrimination models in power lifting thus; it is difficult to compare the results of the current study to that of other studies. Therefore, these variables significantly influenced the sport results in the considered group of sportsmen.

The same variables that were found to be most informative and qualified for the role of the explanatory variables in the regression models were used to build the neural models. For the network with a structure 9-2-1, NRMSE was too high and not satisfactory to claim that this model adjusted well. The network 9-3-1 reached better results than 9-2-1, yet networks 9-2-1

and 9-3-1 showed problems of decreased ability for generalisation (Kurz & Stergiou, 2005). However, the value in validation and test series and the correlation coefficient in those groups (0.96), indicated a necessity of building more models with a larger number of neurons in a hidden layer, which could approximately fit better into the network and learning data in the first set (Kurz & Stergiou, 2005). The quality measures for the network structured as 9-4-1 built for the first 36 cases pointed to a good fit between the model and the training data. However, with 15 new training cases added to the model and following model re-estimation, the results improved. Additionally, the quality measures for all subsets provided strong arguments in favour of the network's high ability to generalise and predict

results and this finding was the main reason for why the investigation was initiated. The practical value of the created model was confirmed by the already mentioned high correlation coefficients: 0.957, 0.961 and 0.979.

In order to test the comparisons of the results that were used to build the regression models and the neural networks, 10 sportsmen whose results were not built into the models were tested. Their FBP results were measured and the quality of the predictions was verified after training. The analysis of the results presented in Table 1 (absolute error modules), shows that the neural models' algorithms were superior to the regression models, as far as the prediction was concerned. The absolute values of the models' error differed by 30kg in favour of the neural model. Additionally, the neural model was of greater accuracy in cases of sportsmen achieving average or poor results. The negative total error of the network indicates that the model makes larger errors in sportsmen with better results in the FBP.

The data collected on a group of 23-year-old sportspersons clearly showed that the neural model predicted sport results better than the regression model, confirming the findings of Bartlett *et al*. (1996), whose non-linear neural models provided predictions of better quality than the multiple regression models. Murakami *et al*. (2005) indirectly proved that neural models are capable of better predictions than non-linear or linear regression models. The opinion that networks with a small number of hidden layers (structure 9-4-1 or 9-3-1) should be preferred in constructing neural models for predicting relationships in the field of sport corresponds to the opinion of Shojaie and Michailidis (2010), expressed in their study, that the networks with one or two hidden layers had the greatest capacity for generalisation.

This study is limited by the number of measured muscle groups, which can be attributed to the shortcomings of the measuring instrument. Another limitation of the study includes the choice of variables evaluated. Only kinematic variables were considered, while individual genetic profiles were not, yet they can significantly influence power (acceleration) and the result of the FBP (Petr *et al*., 2014). The small number of cases can also be considered a limitation of the study, especially when testing the regression model (Maszczyk *et al*., 2012).

The results of the investigation show that the created neural model (9-4-1), offers much higher quality of prediction than created earlier with the regression model for Y1 (FBP). The former generates smaller prediction errors, which directly follow from the absolute error. The optimal set of variables that are most informative and usable as explanatory variables of the non-linear regression models and neural models, for the tested group of the 23-year-old sportsmen for Y1 (FBP results) consists of: maximal velocity during the descending phase; minimal acceleration during the ascending phase; anterior-posterior displacement during the

ascending phase; maximal acceleration during the ascending phase; minimal velocity during the descending phase; *Triceps brachii* activity during the ascending phase; lateral displacement during the ascending phase; vertical displacement during the ascending phase; and the time of the descending phase.

The results explicitly demonstrate that neural models are a tool, which is useful in predicting FBP performance, classifying sportspersons and in optimising the training

process.

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DOES INTENSITY OF PHYSICAL ACTIVITY MODERATE INTER-RELATIONSHIPS AMONG FITNESS, PHYSICAL ACTIVITY AND HEALTH?

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ABSTRACT

The aim of this study was to determine whether perceived intensity of training moderates the physical activity-health, physical activity-fitness, and fitness-health relationships. The participants (N=237) from eight different companies were assessed for participation in physical activity, cardiovascular fitness and health. Fasting blood samples, resting heart rate and blood pressure, as well as body composition measurements were taken. The YMCA three-stage cycle ergometer test was conducted and the ACSM (2010) metabolic and multi-stage equations were utilised to calculate functional capacity in METs. Physical activity was measured with two questionnaires (Sharkey index and Baecke questionnaire), that allows for comparison of relative intensity of training with absolute physical activity scores. ANCOVA and Stepwise Multiple Regression analyses were used to assess the relationships of perceived intensity of training and functional capacity with various measures of health. Perceived intensity of training had marginally moderating effects on physical activity-health ($F=1.135$; $Eta^2=1.7\%$ versus $F=0.228$; $Eta^2=0.4\%$) and the physical activity-fitness ($F=8.5$; $Eta^2=8.5\%$ versus $F=2.35$; $Eta^2=2.5\%$) relationships. Cardiovascular fitness (MET) contributed 9.5% ($p=0.002$) to the variance of a composite health score in comparison to the non- significant ($p=0.470$), 1.2% contribution of intensity of training.

Key words: Perceived intensity of training; Cardiovascular fitness; Coronary risk; Metabolic syndrome; Health.

INTRODUCTION

More than 20 years ago, the American Health Association (AHA) identified physical inactivity as the fourth primary risk factor for Coronary Artery Disease (CAD) (Fletcher *et al*., 1996). However, there is on-going debate concerning the measurement of physical activity (PA), and the prescription dose to optimise health benefits. Williams (2001) ignited the prescription debate with a thought-provoking meta-analysis, concluding that the formalisation of the 1996 ACSM prescription guidelines ensued from inappropriate use of cardiovascular fitness studies. The consequential guidelines demote the importance of cardiovascular fitness, while overstating the public health benefits of moderate amounts of PA, according to Williams (2001).

It is a problem developed due to the use of fitness as a 'surrogate' for PA. A practice historically based on the assumption that fitness reflects PA patterns. Fitness measurements are considered more accurate, while measurement of PA continues to be an elusive concept.

Various PA questionnaires have been developed and tested for validity and reliability over the years (Helmerhorst *et al*., 2012; Scott *et al*., 2013). The majority correlate relatively poorly (r=0.27-0.56) with measures of cardiovascular fitness (Williams, 2001; Shephard, 2002; Warren *et al*., 2010; DaFina *et al*., 2015). Most of these questionnaires are absolute scales that calibrate the intensity of activity based on effort required by healthy, young to middle-aged adults. The International Physical Activity Questionnaire (IPAQ), generally

considered the gold-standard measuring tool, for instance, express PA in absolute terms as MET minutes per week. The IPAQ calculate MET minutes per week by multiplying fixed MET-values for walking (3.3 MET), moderate (4.0 MET) and vigorous activity (8.0 MET) with minutes (duration) and days (frequency) of activity. This process ignores the fact that relative intensity of effort required for the same activity changes as one moves across the physical fitness spectrum. An increasing amount of studies is starting to emphasise the importance of relative intensity of training in terms of health, fitness and measuring PA (Swain, 2005; Franklin, 2007; Kemi & Wisløff, 2010; Rhen *et al*., 2013; DeFina *et al*., 2015; Ramos *et al*., 2015).

Lee *et al*. (2003), for example, found an inverse relationship between relative perceived intensity of PA and Coronary Heart Disease (CHD) risk in older men. The fact that this applied even among those not satisfying current PA recommendations, endorse the importance of relative perceived intensity of training.

RESEARCH PROBLEM AND PURPOSE

The current study proposes that the amalgamation of perceived intensity, duration and frequency into one overall absolute PA score impact negatively on the prediction (cardiovascular fitness and health) qualities of PA questionnaires. The researchers of the current study postulate that when measuring PA, using a relative scale, like the Borg Perceived Exertion and Pain Scale, to gauge the intensity of activity would be more appropriate than absolute scales. Surprisingly, there is a limited amount of published data examining the associations of relative measures of perceived intensity of training with cardiovascular fitness and measures of health.

This study consequently focused on relative perceived intensity of exercise as moderator of health and fitness. Relative and absolute measures of PA were used to study the inter-relationships between PA, physical fitness and health. The aims of this study were:

1. to determine whether relative perceived intensity of training relates better with measures of health than absolute PA scores;
2. to determine whether relative perceived intensity shows better relationships with measures of cardiovascular fitness than absolute measures of PA; and
3. to determine whether relative perceived intensity negates or strengthens the cardiovascular fitness-health relationship.

METHODOLOGY

The data were collected as part of the iWorkWell project, which was conducted by Sport Manawatu on behalf of the Manawatu Mid-Central District Health Board. Participation was voluntary. Two hundred and thirty-seven (N=237) participants from 8 different companies were tested. The mean age of the sample was 39.5 years. Approval was obtained from the Central Regional Ethics Committee (CEN11/04/024).

Procedures and data collection

All testing/data sampling was done at the Exercise Science Laboratory of the Universal College of Learning in Palmerston North, New Zealand.

Anthropometrical measures

Weight was recorded with the shoes and as much other clothes removed as possible. Percentage body fat was obtained using the procedure of 6 skin folds (triceps, subscapula, supra-iliac, abdominal, thigh and medial calf), according to the guidelines of the ISAK (International Society for the Advancement of Kinanthropometry) (2001). A level III Anthropometrist conducted all the measurements.

Biochemical measures

Total cholesterol (TC), low-density lipoprotein-cholesterol (LDL-C), high-density lipoprotein-cholesterol (HDL-C), triglycerides, glucose and the total cholesterol/HDL-ratio (TC/HDL-ratio), were assessed at a registered biochemistry laboratory. Respondents were scheduled for testing over 2 days and were asked to fast for 8 hours prior to blood testing. Non-HDL (TC-HDL), TC/HDL-ratio and Trig/HDL-ratio were calculated.

Physiological variables

The physiological variables that were measured included resting heart rate (RHR) and resting blood pressure (RBP). RBP was measured 3 times after the subjects had rested for 5 minutes in the supine position in a quiet room and the lowest reading was recorded. RHR was measured for a full minute with a stopwatch and stethoscope. Heartbeats were counted and correlated with the readings of a polar heart rate monitor. This was taken after the resting blood pressure measurements.

Coronary Risk Index (CRI)

Coronary risk was assessed using a coronary risk index reflecting the 14 most common or typical risk factors for CAD and utilising a Likert-scale format based on levels of risk (Bjurstrom & Alexiou, 1978).

Illness Rating Scale

Symptomatology was measured through the Seriousness of Illness Rating Scale (IRS) (Wyler *et al*., 1968), a self-reported checklist of 126 commonly recognised physical and mental symptoms and diseases. In the development of this instrument, a general severity weight for each disorder was obtained by asking a large sample of physicians and laypersons to rate each of them. This carefully developed scale of seriousness of illness has served as a tool used frequently in stress and illness studies (Schroeder & Costa, 1984).

Metabolic syndrome score

The ATP III criteria for diagnosis of metabolic syndrome include waist circumference (males >102cm; females >88cm), triglycerides ($\geq$1.70mmol.l^{-1}), HDL-cholesterol (males <1.03mmol.l-1; females <1.30mmol.l-1), systolic blood pressure ($\geq$130mmHg), diastolic blood pressure ($\geq$90mmHg) and fasting glucose ($\geq$6.0mmol.l-1) (Grundy *et al*., 2004). For the purpose of this study the above-mentioned values exceeding the stipulated cut-offs were added into a cumulative metabolic syndrome score. Some sources (Grundy *et al*., 2004) also include elevated LDL-cholesterol as part of metabolic syndrome classification, but for the purpose of this study, the Triglyceride/HDL-ratio was used as a separate marker of health because it provides an estimate of dense LDL molecules (Da Luz *et al*., 2008).

Composite of health

A composite of health was calculated on SPSS using the IRS, CRI, Non-HDL, Trig/HDL-ratio and metabolic syndrome scores. The objective was to reduce the multiple health variables to 1 representative health variable. The inclusion of the metabolic syndrome score

and the Trig/HDL-ratio into a composite of health also combine a more modern understanding of illness and coronary risk pathology with the comprehensive, but dated, Illness rating and CRI scales. Composite scores are particularly convenient when numerous instruments are used to attain a more comprehensive estimation of a diverse construct, such as health. Reducing the data to a composite score make it more manageable especially if the aim is to compare the relationships of more than 1 independent variable with the numerous representative measures of the dependent variable. A new variable is essentially created, which is a mathematical function of all the related variables. The methodology described by Logio *et al*. (2008) was used to calculate the composite score. Composite scores can be unit- weighted or regression-weighted. The unit-weighted approach, used in this study, is to either add all items together or calculating the average of each item. The regression-weighted approach uses a factor analysis. The researchers opted for the unit-weighted approach.

Functional capacity

Baseline physiological assessments of aerobic fitness were done using the YMCA cycle ergometer sub-maximal test protocol (ACSM, 2010). Heart rate was recorded with a heart rate monitor. Karvonen's formula (ACSM, 2010) was used to determine 80% of maximum heart rate (220 – age – RHR × training percentage + RHR). The ACSM (2010) metabolic and multistage equations were used to calculate each individual's relative predicted VO_{2max} and/or functional capacity in METs (VO_{2max} divided by 3.5).

Physical activity

Two measuring instruments were used to access participation in PA, namely the Baecke PA questionnaire (Baecke *et al*., 1982) and the index developed by Sharkey (1984).

By allocating the Borg scale numerical values to the practise requirements, intensity, duration and frequency, the Sharkey method (Sharkey, 1984) expresses participation in PA as an index by multiplying the values with each other. The Sharkey Index measures relative perceived intensity of training with a Likert-type scale where 1 equals light PA, such as fishing and walking, and 5 equal's activity that incite sustained heavy breathing. The Baecke questionnaire also utilises the Likert scale scores for intensity (1=never sweat doing PA to 5=always sweating), duration (1=less than 5 minutes to 5=>45 minutes) and frequency

(1=never to 5=very often), to calculate absolute type scores for work, sport and leisure activity. The leisure index include walking and cycling for transportation purposes (work, school and during shopping). Philippaerts and Lefevre (1998) studied the reliability and validity of the Baecke Index against Doubly Labelled Water (DLW) and found that it provided both reliable and valid PA data.

Data analysis

The inter-relationships between the PA and cardiovascular fitness variables were investigated with partial correlations as part of the first aim of the study. The control variables were age, gender and body weight. This analysis provides information on the relative contributions of the various PA variables with cardiovascular fitness.

The contributions of the PA variables and cardiovascular fitness to health were assessed with a stepwise multiple regression analysis. The dependent variable was a composite of

health. The independent variables were age, gender, body weight, MET, Sharkey dose, Baecke dose, work activity, sport activity, leisure activity and intensity. This analysis was used to compare the relative contributions of intensity of training, PA dose and MET to the variance of the composite of health. The R^2 change values provide information on the amount of variance explained by each variable entered. This analysis offers information for the first and second aims.

Two ANCOVAs were performed using the same control variables as in the partial correlations. The first ANCOVA was performed to assess the dependent and independent relationships of PA dose and intensity of training with all the health variables. Participants were placed into low, moderate and high intensity and PA dose groups based on the group distributions as determined with frequency tables. Those in the upper 30% of the group distribution were classed as high in terms of PA and intensity of training, while those in the bottom 30% were classed as low. The rest were placed in the moderate group. The cut-offs for intensity were 2.5 (n=104) and 4.6 (n=102) for the low and high groups, indicating a normal distribution since the number of respondents above and below the 30 and 70% percentiles were almost the same. The high and low grouping cut-offs for PA dose were 36.0 (n=86) and 63 (n=90) respectively, which also indicate a nearly normal distribution.

In the second ANCOVA, intensity of training and MET was used as independent variables and the composite of health as the dependent variable. The cut-off for the high and low MET groupings were <8.0 MET (n=76) and >9.99 (n=69) respectively. Eta^2 and Wilks Lambda scores were calculated to determine individual and combined contributions of the independent and control variables to the variances of the dependent variable. This analysis provides information relating to the 3rd study aim.

Log data transformation of the dependent variables was done to correct for slight positive skewness. The log transformed variables were checked again for normality and met skewness and standard error (SE) criteria of normality: CRI (skewness=0.343; SE=0.104); IRS (skewness= -0.531; SE=0.204); metabolic syndrome (skewness= -0.160; SE=0.054); Non- HDL (skewness= -0.262; SE=0.104); Trig/HDL-ratio (skewness=0.466; SE=0.204) and composite of health (skewness=0.231; SE=0.104).

RESULTS

Descriptive characteristics of participants

The average age of the 237 participants was 39.5 years. Almost 60% of this group were women (Table 1). The mean VO_{2max} of the participants was 31.4ml.kg^{-1} (8.97 MET x 3.5), which is a moderate level of cardiovascular fitness. Of the group, 32.1% (n=76) had a functional capacity lower than 8.0 MET, while 29.1% (n=69) had functional capacities higher than 10.0 MET. A Sharkey PA dose value of 45 equates to more or less 1000kcal.week^{-1} (Dreyer & Strydom, 1994). The group mean of 57.4, therefore, indicates a cohort of participants that was moderately physically active. A Sharkey dose value of 36.0 represents a kilocalorie expenditure of 450kcal.week^{-1}, while 63.0 equates to about 1500kcal.week^{-1} (Dreyer & Strydom, 1994). A total 36.3% (n=86) of the participants were below the 450kcal.week^{-1} cut-off and 37.9% (n=90) above the 1500kcal.week^{-1} cut-off.

TABLE 1. **DESCRIPTIVE CHARACTERISTICS OF PARTICIPANTS**

Variables	Total (N=237) Mean±SD	Women (n=142) Mean±SD	Men (n=95) Mean±SD
Age	39.50±12.10	40.20±12.00	35.20±12.00
Weight (kg)	79.30±18.90	73.20±15.80	87.30±19.90
Body Fat (%)	21.90±9.80	27.40±8.40	14.40±6.10
BMI	27.20±5.60	26.90±5.50	27.50±5.80
Health			
IRS	258.70±205.70	317.90±218.30	253.50±193.10
CRI	24.50±7.20	23.50±6.87	25.50±7.30
MS-score	1.72±1.10	1.57±1.10	1.95±1.13
Non-HDL	3.80±0.95	3.76±0.90	3.85±0.95
Trig/HDL-ratio	0.88±0.66	0.80±0.60	1.01±0.74
C-V capacity			
PWC_{170}	2.04±0.62	1.83±0.52	2.33±0.62
MET	8.97±2.21	8.33±2.05	9.83±2.16
Physical activity			
Sharkey index	57.40±47.29	53.50±48.70	64.90±44.70
Intensity	3.80±2.78	3.39±2.87	4.21±2.68
Duration	6.54±4.66	5.97±4.98	7.11±4.34
Frequency	5.62±3.90	5.38±4.39	5.87±3.41
Baecke index	2.48±0.58	2.35±0.56	2.60±0.59
Work activity	2.28±0.40	2.30±0.41	2.26±0.39
Sport activity	3.02±1.33	2.72±1.31	3.32±1.34
Leisure activity	2.14±0.57	2.04±0.55	2.23±0.58

IRS=Illness Rating Scale CRI=Coronary Risk Index BMI=Body Mass Index; MS-score=Metabolic Syndrome score C-V capacity=Cardiovascular capacity

Relationships between physical activity and cardiovascular fitness variables

Partial correlations were calculated firstly, to determine the relationships between the measures of PA and cardiovascular fitness, while controlling for age, weight and gender (Table 2). The r^2, which provides information on shared variance and coefficient of

determination, are indicated in brackets. The lowest r^2 was 0.6% (work activity with PWC_{170}) and the highest 20.3% (Baecke PA dose and sport activity with PWC_{170} and MET). This shows that the effect of PA and the cardiovascular fitness variables on health, as investigated in the ANCOVAs, are not confounded. It also provides information on which of the PA variables shows the most meaningful coefficient of determination to the variances of the cardiovascular fitness variables.

TABLE 2. **PARTIAL CORRELATIONS# OF PHYSICAL ACTIVITY WITH CARDIOVASCULAR FITNESS**

Physical activity measures	PWC_{170}	METS
Sharkey PAI	0.39* (15.2%)	0.39* (15.2%)
Intensity	0.37* (13.7%)	0.37* (13.7%)

Overall Baecke	0.45* (20.3%)	0.45* (20.3%)
Work activity	0.08 (00.6%)	0.09 (00.8%)
Sport activity	0.45* (20.3%)	0.45* (20.3%)
Leisure activity	0.27* (07.3%)	0.28* (07.8%)

Values in brackets: r^2 x 100 *=p<0.05 # Controlling for age, weight, gender

PA dose, as measured with the Baecke questionnaire, correlates slightly better (r=0.45 versus r=0.37) with cardiovascular capacity (PWC_{170} and MET), than relative perceived intensity of exercise (Table 2). The Baecke sport activities subscale (r^2 x 100= 20.3%) and the Sharkey intensity of training scale (r^2 x 100=13.7%), are markedly better contributors to the variance of MET than the other 2 Baecke subscales (work activity=0.8% and leisure activity=7.8%).

Physical activity and cardiovascular fitness as predictors of health

A stepwise multiple regression analysis was performed to compare the contributions of intensity of training and the other PA variables, as well as cardiovascular fitness to the variance of the composite of health. This analysis provides information on the overall theme of the study, namely the moderating effect of intensity of training on the relationships of PA dose and cardiovascular fitness to health. In total 10 independent variables (age, gender, body weight, MET, Sharkey dose, Baecke dose, work activity, sport activity, leisure activity and the Sharkey intensity scale), were used in this analysis. Only 6 of the variables (body weight, MET, Sharkey dose, intensity, work activity and leisure activity), were listed as contributors to the composite of health in the stepwise regression output. The major contributor was body weight (F=37.5; R^2=0.214; p=0.000).

The other significant contributors were MET (F=23.9; R^2=0.117; p=0.000), relative intensity of training (F=4.99; R^2=0.023; p=0.027) and Sharkey dose (F=4.04; R^2=0.019; p=0.046). Work activity and leisure activity were listed as non-significant contributors. In terms of the aims of the study, the important information gained from this analysis is that the relative intensity scale contributed slightly more (2.3%) to the variance of the composite of health

than PA dose (1.9%), but markedly less than MET (11.7%). The 6 independent variables in Table 3 contributed as a group 38.7% to the variance of the composite of health.

TABLE 3. **STEPWISE MULTIPLE REGRESSION ANALYSIS TO PREDICT A COMPOSITE OF HEALTH**

Predictor variables	Multiple R	Multiple R^2	R^2 change	F-value	p-Value
Body weight	0.463	0.214	0.214	37.60	0.000
MET	0.575	0.331	0.117	23.90	0.000
Sharkey dose	0.592	0.350	0.019	4.04	0.046
Intensity	0.611	0.373	0.023	4.99	0.027
Work activity	0.616	0.379	0.006	1.39	0.239
Leisure activity	0.622	0.387	0.007	1.45	0.231

Note: No control variables were used in this analysis.

Dependent and independent relationships of intensity of training and physical activity dose with health

The individual and combined relationships of intensity of training and an overall PA score to cardiovascular fitness (METs) and measures of health was investigated with a ANCOVA. The covariates were age, gender and body weight.

TABLE 4. **RELATIONSHIPS OF OVERALL ACTIVITY AND INTENSITY OF TRAINING WITH MEASURES OF CARDIOVASCULAR FITNESS AND HEALTH: ANCOVA ANALYSIS**

Dependent variables	ANCOVA variables	F-ratio	p-Values	Eta^2	Wilks Lambda
MET	Gender	31.160	0.000	0.145	53.6%
	Age	16.106	0.000	0.081	
	Body weight	15.558	0.000	0.078	
	Intensity level	8.530	0.000	0.085	
	MET level	2.350	0.098	0.025	
	Combined	1.577	0.182	0.033	
	Overall model	14.388	0.000	0.464	
IRS	Gender	15.193	0.000	0.077	86.8%
	Age	0.046	0.831	0.000	
	Body weight	8.884	0.003	0.046	
	Intensity level	2.029	0.134	0.022	
	MET level	1.008	0.367	0.011	
	Combined	0.818	0.515	0.018	
	Overall model	2.528	0.005	0.132	

TABLE 4. **(cont.)**

Dependent variables	ANCOVA variables	F-ratio	p-Values	Eta^2	Wilks Lambda
CRI	Gender	0.001	0.970	0.000	56.7%
	Age	42.349	0.000	0.188	
	Body weight	48.782	0.000	0.210	
	Intensity level	1.516	0.222	0.016	
	MET level	0.676	0.510	0.007	
	Combined	0.301	0.877	0.007	
	Overall model	12.705	0.000	0.433	
Non-HDL	Gender	0.463	0.498	0.004	82.6%
	Age	7.793	0.006	0.057	
	Body weight	8.253	0.005	0.061	
	Intensity level	1.218	0.299	0.019	
	MET level	0.115	0.892	0.002	
	Combined	0.857	0.492	0.026	
	Overall model	2.455	0.008	0.174	
Trig/HDL-ratio	Gender	0.048	0.827	0.000	80.9%
	Age	6.175	0.014	0.046	
	Body weight	18.322	0.000	0.125	
	Intensity level	0.569	0.568	0.009	
	MET level	0.717	0.490	0.011	
	Combined	0.491	0.742	0.015	

	Overall model	2.750	0.003	0.191	
Metabolic syndrome score	Gender	0.175	0.677	0.001	67.1%
	Age	23.537	0.000	0.155	
	Body weight	19.658	0.000	0.133	
	Intensity level	0.770	0.465	0.012	
	MET level	1.542	0.218	0.024	
	Combined	0.180	0.948	0.006	
	Overall model	5.693	0.000	0.329	
Composite health score	Gender	0.455	0.501	0.004	56.8%
	Age	32.549	0.000	0.203	
	Body weight	49.242	0.000	0.278	
	Intensity level	1.135	0.325	0.017	
	MET level	0.228	0.797	0.004	
	Combined	0.106	0.980	0.003	
	Overall model	8.833	0.000	0.432	

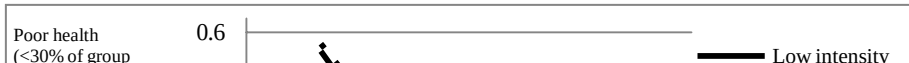
The F-ratio, p-values and ETA^2 values of each of the independent variables, the combined variables and the control variables are presented in Table 4. Intensity of training contributed more to the variance of MET (8.5% versus 2.5%), IRS (2.2% versus 1.1%), CRI (1.6% versus
0.7%), Non-HDL (1.9% versus 0.2%) and the composite health score (1.7% versus 0.4%), than the overall activity score. The contribution of intensity was statistically significant (p=0.000) only in the case of MET. PA dose showed a marginally higher contribution to the variance of Trig/HDL-ratio (1.1% versus 0.9%) than intensity of training. Body weight was the only variable that showed a statistically significant relationship with all 6 dependent variables in Table 4.

Dependent and independent relationships of intensity of training and cardiovascular fitness with a composite of health

In order to assess the moderating effect of intensity of training on the fitness-health relationship, a second ANCOVA was performed. The composite of health showed very similar relationships with the PA measures as the other health variables in the first ANCOVA. In order to condense and focus the discussion only the composite of health was used in the second ANCOVA (Table 5).

TABLE 5. **RELATIONSHIPS OF METS AND INTENSITY OF TRAINING WITH A COMPOSITE HEALTH SCORE: ANCOVA ANALYSIS**

Variables	**F-ratio**	**p-Values**	**Eta^2**	**Wilks Lambda**
Gender	2.265	0.135	0.017	64.0%
Age	0.048	0.827	0.000	
Body weight	23.301	0.000	0.154	
Intensity level	0.765	0.470	0.012	
MET level	6.753	0.002	0.095	
Combined	0.346	0.847	0.011	
Overall model	6.559	0.000	0.360	



	MET; 30%)		MET; 70%)
Low intensity exercise	0.388	0.003	-0.205
Mod intensity exercise	0.559	-0.099	-0.583
High intensity exercise	0.533	-0.204	-0.577

FIGURE 1. **ASSOCIATION BETWEEN PERCEIVED INTENSITY OF TRAINING AND COMPOSITE OF HEALTH STRATIFIED BY INTENSITY OF TRAINING**

The control variables were age, gender and body weight. Body weight (F=23.301; p=0.000) and MET (F=6.752; p=0.002) were the only statistically significant contributors to the variance of the composite health score in this analysis. Cardiovascular fitness (MET) contributed 9.5% (p=0.002) to the variance of the composite health score in comparison to the non-significant (p=0.470), 1.2% contribution of intensity of training.

The results of the ANCOVA reported in Table 5 are illustrated schematically in Figure 1. It reveals that moderate and high perceived intensity of training do not coincide with better health in the low fitness group (<8 MET). Those classified as low fit had mean composite health scores in the bottom 30% of the group distribution irrespective of level of participation in PA. In contrast, a downward trend can be observed in the low, moderate and high intensity groups in correspondence with level of cardiovascular fitness. As fitness increases the composite health score decreases, which indicates better health. The fitness-health improvements are nevertheless markedly steeper in the moderate and high perceived intensity cohorts (109.8% and 108.3%), as compared to the low intensity cohort (52.8%).

DISCUSSION

Figure 2 provides an illustration or model of the interactions between PA, fitness and health that is under scrutiny in this study. The model indicates that A (PA) leads to B (physical fitness) and that both A and B lead to C (Health). The model also positions that A and B do not necessarily influence each other's relationships with C.

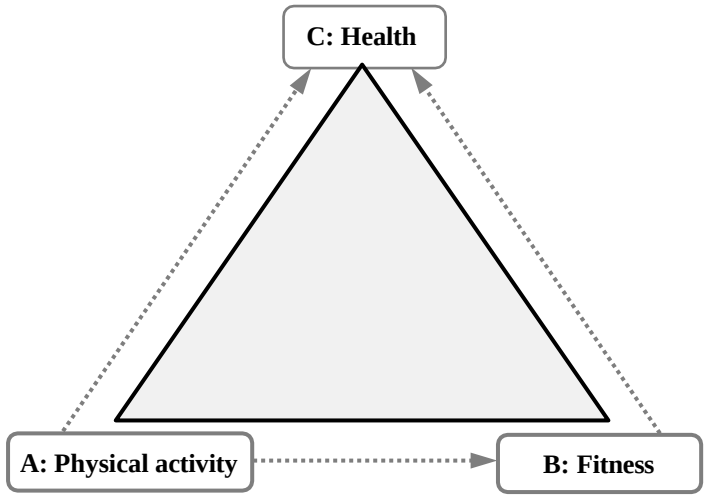


FIGURE 2. **MODEL OF PHYSICAL ACTIVITY, FITNESS AND HEALTH INTER-RELATIONSHIPS**

The scientific angle of the present study is that it is more appropriate to test the interactions between fitness, PA and health with a relative measure of perceived intensity as opposed to an absolute measure of PA. In short, the moderating impact of a relative measure of perceived

intensity of training on the AB, AC and BC relationships in an apparently healthy population were investigated.

More specifically, the aims of this study were to determine whether relative perceived intensity of training moderates the PA-health (AC-line in Figure 2), PA-fitness (AB-line) and fitness-health (BC-line) relationships. The results indicate that perceived intensity of training had marginal moderating effects on the PA-health (AC) and the PA-fitness (AB) relationships. Perceived intensity of training had no moderating effect on the cardiovascular fitness-health (BC) relationship in the low fitness group and small moderating effects in the moderate and high fitness groups. The contribution of the measures of PA condenses to negligently small units in the presence of moderate and high levels of cardiovascular fitness.

Intensity as moderator of the physical activity-health (AC) relationship

The IPAQ questionnaire is widely considered the gold-standard PA questionnaire. The IPAQ questionnaire classifies all activity as either low, moderate or vigorous and not on a relative intensity continuum like the Borg Perceived Exertion and Pain Scale (RPE). Metabolic equivalents for walking and activities perceived to be moderate and vigorous are multiplied by days and minutes in the process of calculating MET/minute/week scores. In this way, job, transportation, domestic and sport/recreation PA's are expressed in absolute terms as MET/minutes/week (IPAQ, 2005). Defining intensity using an absolute scale in METs may be limited because it neglects variations in physical fitness.

In terms of the aims of the current study, the IPAQ scores were consequently considered 'contaminated' by fitness level, as well as by duration and frequency of training. What was needed for this study was a measure of relative perceived intensity and not an absolute PA score. Consequently, a relative intensity index developed by Sharkey (1984) was utilised, which has a Likert-like format, like the Borg RPE scale.

The Borg RPE Scale (Borg, 1998), is commonly used during exercise stress testing. Good correlations exist between ratings on this scale and heart rate (r=0.80 to 0.90), during graded exercise testing (Borg, 1998; Lee *et al*., 2003). Lee *et al*. (2003) used the Borg scale to rate exertion levels of habitual physical exercise of 7337 men. Participants were asked, "When you are exercising in your usual fashion, how would you rate your level of exertion (degree of effort)?" Men responded using a scale ranging from 0 ("nothing at all") to 10 ("maximal"). They found a dose-response relation with greater decrements in CHD rates at higher relative perceived intensities. This applied even to men not fulfilling current recommendations for PA. On the other hand, the absolute intensity of PA did not perform as well in distinguishing CHD risk groups (Lee *et al*., 2003).

Relative perceived intensity of training contributes more to the variances of virtually all the measures of health (IRS, CRI, Non-HDL and a composite of health), than the absolute PA scores (Table 4). The exceptions were the metabolic syndrome score (2.4% versus 1.2%) and the Trig/HDL-ratio (1.1% versus 0.9%).

Intensity as moderator of the physical activity dose-fitness (AB) relationship

A marginal tendency seemed to exist in the data that perceived intensity moderates of the PA dose-fitness (AB) relationship. The largest coefficient of determination (r^2) value was 20.3% (Table 2), indicating that, in this population, cardiovascular capacity (MET) is not an exclusive product of participation in physical exercise. Research on genetic determination of cardiovascular fitness indicates that genes account for 40 to 50% of individual variation in VO_{2max} (Bouchard *et al*., 1999). Cardiovascular fitness is clearly not an exclusive product of PA. Therefore, it is unrealistic to expect close to perfect correlations between measures of PA and cardiovascular fitness. High cardiovascular fitness is an indication of a highly integrated and well-functioning oxygen transport system free of pathological conditions. Genetics, underlying pathology, body composition, type of training/fitness testing can all influence how well PA patterns reflect cardiovascular status. The current data support the idea that fitness and PA (even if of high intensity), are separate entities that should be treated as separate risk factors. Maybe fitness status assessment should play an integral part in the cardiovascular risk paradigm.

In terms of measuring/assessing PA, the Sharkey intensity index did not excel as an outstanding predictor of fitness in this study. This was a slightly different outcome from what was expected and might be because the Sharkey relative intensity scale (stretching from 1 for light to 5 for sustained heavy breathing), has a ceiling effect. The intensity choices provided might not be broad enough to distinguish with apt exactitude between levels of intensity.

Paffenbarger *et al*. (1993) compared the average weekly exercise records of 107 women and 457 men over six months before they completed a maximal exercise test on a treadmill. They found correlations ranging from r=0.66 to r=0.83 across groups of younger and older

men and women. Dreyer *et al*. (2012) reported a correlation of r=0.65 between intensity of physical training and change in VO_{2max} in clients that completed a 10-week exercise intervention program. Both these studies scored activity with the Cooper Clinic point system that corrects for intensity in the sense that the overall score are adjusted according to the time it takes to complete set workouts. The Cooper system adjustment for time is different from the IPAQ adjustments. The IPAQ multiply the vigorous days with activity minutes. The consequence is that it adjusts negatively for speed, whereby a higher score is attained if the perceived 'vigorous' run is slower. In contrast, the Cooper points system adjusts positively for speed by achieving a higher score if it takes fewer minutes to complete a set task/run/distance. The above findings support the idea that a more precise assessment of intensity might increase the fitness predictive qualities of PA questionnaires.

Helmerhorst *et al*. (2012) did a systematic review of reliability and objective criterion-related validity of PA questionnaires. They concluded that the validity of PA questionnaires was moderate at best. They emphasise the importance of accurate assessment of intensity levels as part of improving the validity of PA questionnaires. Scott *et al*. (2013) published a guide to the assessment of PA and stated that there is no single best instrument appropriate for every situation. It was against this backdrop that the Sharkey intensity index was trailed in the current study. The results of this study indicate that it lacks precision as a predictor of fitness, but not more so than the Baecke questionnaire, which is one of the better PA questionnaires, according to Helmerhorst *et al*. (2012).

Intensity as moderator of the fitness-health (BC) relationship

Intensity of training faded as a contributor to the composite health score when cardiovascular fitness (expressed as MET), was included as a predictor variable. The same applied to duration, frequency, work, sport and leisure activity measures. Therefore, physical exercise (whether of perceived high intensity and of long duration and/or at high frequency), did not equate to better health in the presence of low cardiovascular fitness in this analysis (Table 3).

The fact that the composite of health dropped by 52.8% across the fitness groups in the low-intensity group (Figure 1), indicates that fitness has health benefits independent of perceived intensity of exercise. A steeper downward trend across the fitness groups in the moderate and high perceived exercise intensity groups (109.8 and 108.3% respectively, versus 52.8% in the low-intensity group), exist. It suggests that perceived intensity of training has a positive effect on the cardiovascular fitness-health (BC) relationship. Similarly, Williams (2001) reported a 60% decline in risk for cardiovascular disease from the least-fit to the most-fit, in contrast to a 30% decline in risk from the least-active to most-active.

That high-intensity exercise leads to greater fitness benefits (as compared to low and moderate intensity exercise), is not a new concept. What is new is the increasing awareness of how important intensity of training is in the case of health and rehabilitation. Kemi and Wisløff (2010) suggest that a threshold of intensity may exist for improving the heart's mechanical efficiency. In a multivariable meta-regression analysis, Uddin *et al*. (2015) found only exercise intervention intensity to be significantly associated with VO_{2max} ($P = 0.04$) in patients with coronary heart disease and heart failure. In terms of study limitations, the cross- sectional design of the present study averts cause and effect conclusions. The

study cohort also presents a relatively healthy group of adults ≥20 years. A similar study on individuals with co-morbidities is required. Future research could also benefit from using broader relative intensity scales and accelerometers.

PRACTICAL IMPLICATIONS

The practical implications of the findings of this study are that PA and cardiovascular fitness should be considered partly distinct components of health. Poor fitness and physical inactivity should be considered separate and inter-related risk factors. The findings leave the impression that the use of relative measures of intensity of training might positively affect the predictive (health and fitness) accuracy of PA questionnaires. Data from the current study and the literature quoted confirm that exercise of higher perceived intensity equates with better health outcomes. However, high-intensity exercise did not parallel with better health in the absence of moderate and high levels of fitness. Therefore, the data could also indicate that exercise for health needs to be of sufficient intensity to improve levels of cardiovascular fitness (Williams, 2001; Franklin, 2007; Kemi & Wisløff, 2010; Tjønna *et al*., 2013; DaFina *et al*., 2015). Rhen *et al*. (2013:5) states in this regard: "The question today is not whether physical activity per se has beneficial effects. The question is how to attain a sufficient level of high- intensity physical activity in all strata of the population."

CONCLUSIONS

Ultimately, cardiovascular fitness emerged as a potent marker of health in this study. Physical exercise on the other hand did not equate with better health in the absence of at least reasonable levels of fitness in this cross-sectional study of a selection of the workforce in the Manawatu region in New Zealand.

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ANALYSIS OF SHOTS ON TARGET AND GOALS SCORED IN SOCCER MATCHES: IMPLICATIONS FOR COACHING AND TRAINING GOALKEEPERS

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ABSTRACT

The aim of this study was to analyse the characteristics and patterns of shots on target and goals scored during the 2012-European Championship. The broadcasted matches were recorded and converted into electronic video files for a computer- based analysis. This quantitative study examined 31 matches of the championship and identified 123 shots on target (which were not goals) and 73 goals scored. The results revealed that 88 (72%) shots on target and 39 (53.4%) goals scored were aimed at the low zones of the goalposts. Goalkeepers blocked 80 shootings (65%) from outside of the penalty area, whilst 65 goals (89%) were scored inside the penalty area. Based on the low zones of the goalposts and shooting angles, 72 shots on target and goals scored were from different angles and 55 were from the same angles. There was a significant difference (χ^2=20.61; p<0.001) between the 26 goals from different angles and the 13 goals from the same angles in the low zones of the goalposts. Methodical training programmes for low-flying balls, body movements, decision-making and cooperative defence strategies were recommended for goalkeeper training.

Key words: Soccer; 2012-European Championship; Match analysis; Goalkeeper

training.

INTRODUCTION

Soccer is a team sport, which is characterised by flamboyance, teamwork, interaction, physical ability, mental ability and so on. Economically, soccer as a commercial sport is a distinctively lucrative business, which attracts numerous spectators around the world. The quality of soccer matches as a valuable product has been the overriding concerns of not only marketers and soccer fans, but also coaches and players. In relation to the increase and maintenances of the quality of soccer games, some researchers have conducted investigations into the key elements of soccer games and their characteristics. The most common analysis is match analysis such as objective recording and examination of soccer activities and the outcome is a description of playing patterns (Carling *et al.*, 2005).

In soccer matches goals are one of the most important pinnacles to determine the success and failure of soccer teams (Cachay & Thiel, 2000; Michailidis *et al*., 2004; Leite, 2013a, 2013b). Mostly useful goal patterns in tournaments or leagues have been researched, such as (1) to understand trends of performance of modern soccer games and to anticipate the future aspects of soccer performance (Jones *et al.*, 2004); (2) to record relevant variables as the tactics of the game are always changing, enabling those who are interested to follow the changing aspects (Yiannakos & Armatas, 2006); and (3) to transfer knowledge to coaches, players and even researchers, which is very useful for planning, deciding and executing game preparation and training (Garganta *et al.*, 1997). In this respect, there have been several studies that focused on the patterns of goals, timing, tactics, etc., that occur during soccer competitions (Olsen, 1988; Jinshan *et al*., 1993; Garganta *et al*., 1997; Michailidis *et al*., 2004; Yiannakos & Armatas, 2006; Armatas *et al*., 2009; Armatas & Yiannakos, 2010; Leite, 2013a, 2013b; Michailidis *et al*., 2013; Mitrotasios & Armatas, 2014).

By analysing soccer games this study identified other useful facts to consider, which have to date not been covered fully in current literature. A goalkeeper conducts a double function, namely as a first attacker and a last defender, thus playing an important role in characterising the game itself through his/her decisive decision-making and performance (Paz-Franco *et al*., 2014). No one could deny the importance of basic skills and strategies, such as decision- making, motor performance and even cooperative defence in relation to the performance of a goalkeeper. However, goalkeepers have been relatively neglected due to the lack of developing specific training methods for goalkeepers and conducting constant research.

In the literature, some research has been reported about the performance of soccer goalkeepers in game situations, such as penalties and crosses (Wilson *et al*., 2009; Wood & Wilson, 2010; Yoon *et al*., 2012), diving saves and their movements (Spratford *et al*., 2009), the characteristics of the defence intervention of goalkeepers (Sainz de Baranda *et al*., 2008), and their perception and response in general (Knoop *et al*., 2013). Lee *et al*. (2007) addressed what a goalkeeper needs, such as basic skills, cognitive and operational capability and psychological strength to endure pressure during the game.

Coaching and training goalkeepers would need various information sources elicited from the game itself. In this respect, the current study conducted match analyses, especially regarding the combination of shooting areas, shots taken on target and scoring goals and

characteristics that have not been fully covered in previously published research. These match analyses could benefit offensive players, as well as defensive players, especially goalkeepers and coaches in terms of specific training content and design, aiming at improving basic defensive skills and adapting to various circumstances (Hughes, 1996; McGarry & Franks, 2000; Savelsbergh *et al*., 2002; Hughes & Franks, 2004). In particular, this study investigated some useful information, such as the heights and directions of goals especially from a training perspective for goalkeepers. The 2012-UEFA European Championship held in Poland and Ukraine was selected as the event and source for the collection and analysis of data.

PURPOSE OF THE STUDY

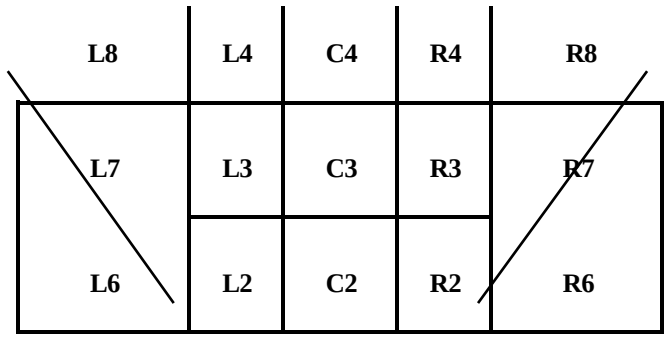
The objectives of this study can be summarised as follows:

(1) To identify shooting areas, shots on target and goals scored which goalkeepers had to deal with during the matches of the Championship;
(2) To reveal where shots were produced and where the balls were targeted in the goal area;
(3) To arrange the patterns in relation to the combination of shooting areas and shots on target and goals scored;
(4) To identify useful implications for goalkeeper coaching and training through the match analysis; and
(5) To record the Championship for future research opportunities, such as accumulating data and comparing the results with other competitions.

METHODOLOGY

Sample

Between 8 June 2012 and 1 July 2012, all matches (N=31) of the 2012-UEFA European Championship were analysed. The games produced 196 shootings (123 shots on target and 73 goals scored), except for 3 penalty-kick goals that were identified in the tournament. For the analysis of the shootings (shots at goal) in this study, the shooting areas were divided into 20 zones (Figure 1) to indicate the spots from which shots at goal were produced. The zones L8, L4, C4, R4 and R8 are on the outskirt of Area Zone and the rest are the goal and penalty area.



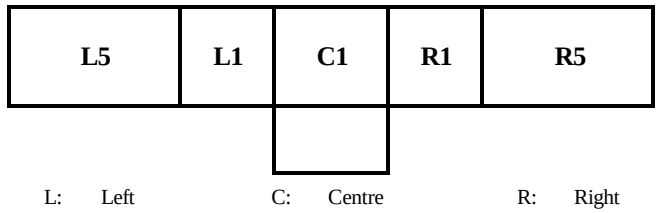


FIGURE 1. **AREA ZONE**

The grid style segmentation was used to secure goal-related basic data for future research. The goal scoring area between the goalposts was divided into 9 goal zones to identify the spot at which the ball found the net. All shots on target and scored goals were identified in one of these 9 goal zones (Figure 2). For the purpose of this study, the total valid shots were separated into shots on target and goals scored. To clarify this terminology, "shots on target" means goalkeepers block shot balls, whilst "goals scored" means goalkeepers missed the shot,

allowing a goal to be scored. The directions (Left, Centre, Right) are positioned in Figure 1 and 2, as the reader would be viewing it, to avoid unnecessary confusion.

Lc	**Cc**	**Rc**
Lb	**Cb**	**Rb**
La	**Ca**	**Ra**

L=Left C=Centre R=Right

FIGURE 2. **GOAL ZONES**

Procedures

The matches were analysed using video analysis by 3 trained observers. The inter-rater reliability was calculated to guarantee the quality of the results of the observation. A reliability coefficient of 0.95 was attained (intra-class correlation coefficient and Kappa index). The procedure of analysis was applied in 3 distinct stages. Firstly, video captures of shots on target and goals scored were conducted by examining all of the matches of the 2012- European Championship. For this purpose, the complete broadcasted matches were recorded and converted into electronic video files using the SPORT CODE GAMEBREAKER 10.24 software program. In the second stage, the captured data were analysed to identify the pattern of shot locations based on the Area Zone and the spots of each shot on target and goals scored based on the Goal Zone. Lastly, the collected data were coded for statistical analysis.

Analysis of data

For the purpose of this study, descriptive statistics comprising of frequency distribution was used. The statistical data were also presented with Absolute Frequency and Relative Frequency for shots on target, goals scored and the combination of the Area Zone and the Goal Zone. Cross-tabulation analysis was applied to verify any significant differences between variables. For the Chi-Square analysis to determine statistically significant differences, $p<0.05$ was set as the significant level. All data used in this study were analysed by the statistical package, PC SPSS 12.0.

RESULTS

In the 2012-European Championship, 123 shots were on target and blocked by goalkeepers, whilst 73 goals were scored which excluded 3 penalty goals. In terms of the *shots on target*, the analysis revealed that 33 (26.8%) shots targeted the Ra-zone of the Goal Zone, 28 (22.7%) shots were in the Ca-zone and 27 (22%) in the La-zone. The balls targeting the low zones (La, Ca, Ra) of the Goal Zone consisted of 88 (71.5%) out of 123 shots on target. In the middle zones (Lb, Cb, Rb) of the Goal Zone, 14 shots were on target (11.4%), while 21 shots (17.1%)

were targeted at the high zones (Lc, Cc, Rc). A statistically significant difference was found for the low zone (Ra, Ca, La) when compared to the middle zone (Rb, Cb, Lb) and high zone (Rc, Cc, Lc) (χ^2=81.41; $p<0.001$).

In relation to the *goals scored*, 14 (19%) goals were identified in the Ra-zone of the Goal Zone, followed by 13 (18%) in the La-zone, 12 (16.4%) in the Ca-zone, 9 (12.3%) in the Rb-
zone and 8 (11%) in the Cc-zone. There were 39 goals (53.4%) scored during the 2012-European Championship in the low zones of the Goal Zone (Ra, Ca, La), 16 goals (21.9%) in the middle zones (Lb, Cb, Rb) and 18 goals (24.7%) were in the high zones (Lc, Cc, Rc). There was a statistically significant difference in the low zones (Ra, Ca, La) when compared to the middle zones (Rb, Cb, Lb) and high zones (Rc, Cc, Lc) (χ^2=13.34; $p<0.001$).

The findings also indicate some patterns of the total number of shots. More specifically, 47 (24%) shots on target and goals scored were founded in Ra of the Goal Zone, 40 (20.4%) in each of the La-zone and the Ca-zone, followed by 22 (11.2%) in the Cc-zone. The total frequency of shots on target and goals scored on the low zones of the Goal Zone was 127 (64.8%), while 30 (15.3%) shots on target and goals scored were identified in the middle zones and 39 (19.9%) were in the high zones of the Goal Zone. There was a statistically significant difference in the low zones (Ra, Ca, La) compared to the middle (Rb, Cb, Lb) and high zones (Rc, Cc, Lc) (χ^2=87.92; $p<0.001$). Figure 3 summarises the total frequency and patterns of shots on target and goals scored found in the matches played at the European Championship in 2012.

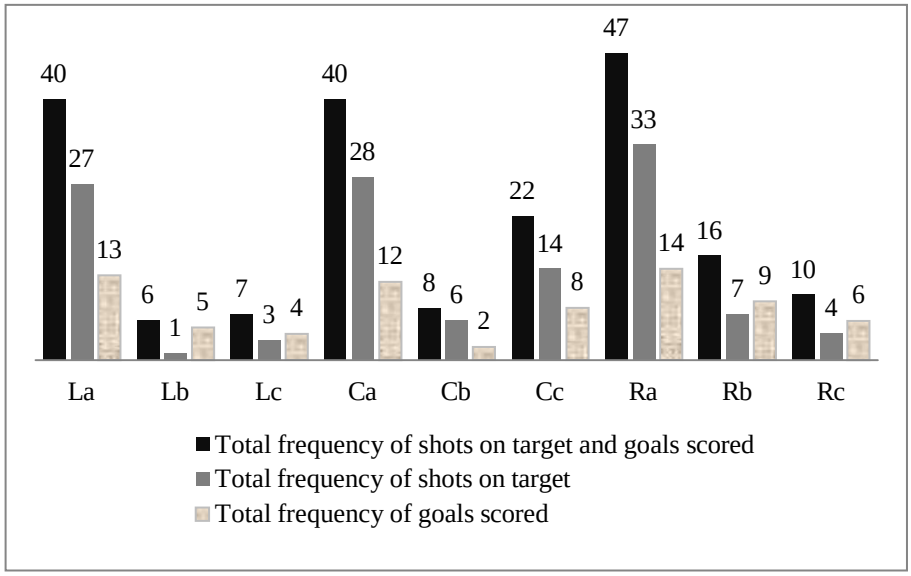


FIGURE 3. **TOTAL FREQUENCY AND PATTERNS OF SHOTS ON TARGET AND GOALS SCORED**

With reference to the *Area Zone*, a total 28 shots on target (22.8%) were identified in C4, followed by 25 (20.3%) in R8, 15 (12.2%) in L8, 7 (5.7%) in L7, 7 (5.7%) in R4 and 6 (4.8%)

in R7. On the outskirts of the Area Zone (C4, R4, R8, L4, and L8), there were 80 shootings, which is 65% of the total 123 shots on target. Inside the Area Zone, 43 (35%) shots were tried on target. There was a statistically significant difference in shots on target from the outskirt of the Area Zone compared to the rest (χ^2=13.66; p<0.001). Figure 4 illustrates the individual shooting positions in relation to shots on target during the European Championship 2012.

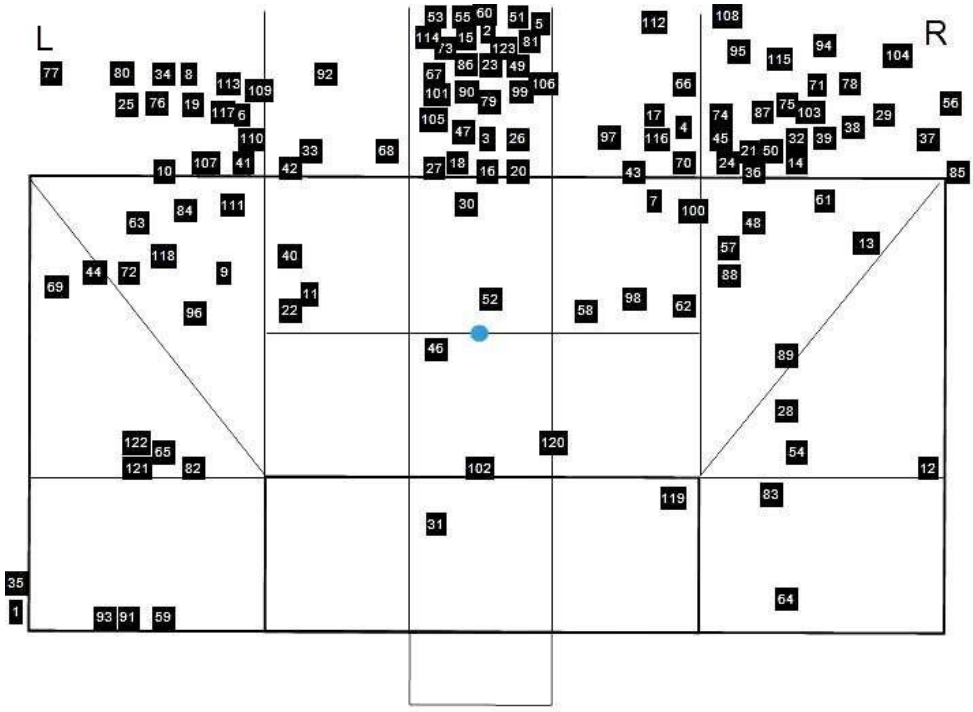


FIGURE 4. **INDIVIDUAL SHOOTING POSITIONS IN AREA ZONE WITH SHOTS ON TARGET (not scored)**

Concerning the shootings made in C2, 15 goals (20.5%) were scored, while 11 goals (15.1%) were score in C1, followed by 7 (9.6%) in C3 and 5 (6.9%) in L2, L3 and R3. In the goal and penalty area (C1, C2, C3, L1, L2, L3, R1, R2, R3), 65 goals were scored, which was 89% of the total 73 goals. On the outskirts of the Area Zone (C4, R4, R8, L4, L8), 8 goals (11%) were scored. There was a statistically significant difference in goals scored from inside the penalty area of the Area Zone compared to the outskirts area (χ^2=61.49; p<0.001). Figure 5 illustrates the individual shooting positions from which goals were scored during the Championship.

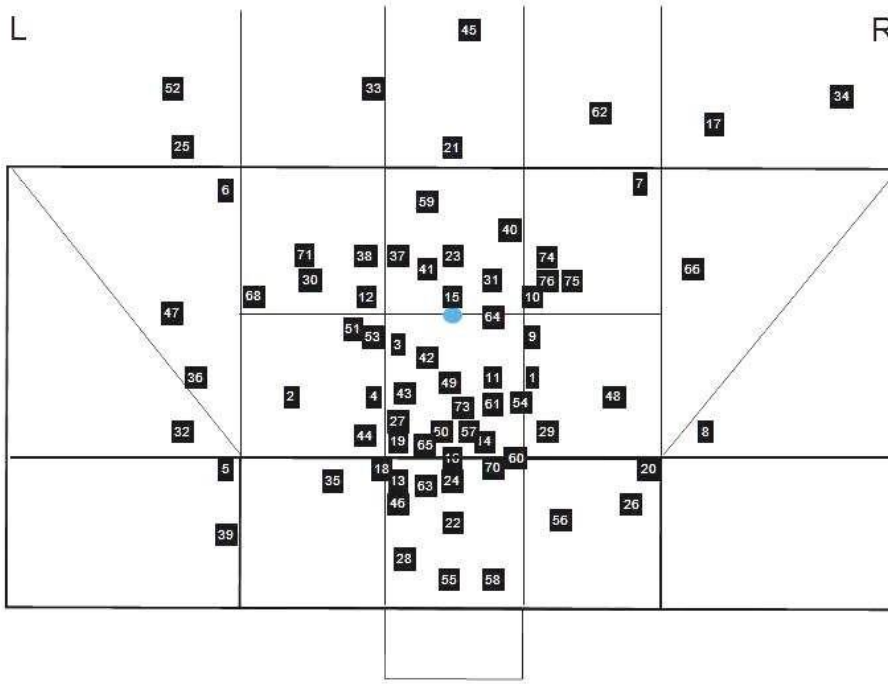


FIGURE 5. **INDIVIDUAL SHOOTING POSITIONS IN AREA ZONE WHEN GOALS SCORED**

Table 1 classifies the total shots on target and goals scored in order to organise the whole configuration of shootings in terms of combinations of the Area Zone and the Goal Zone. Table 1 shows, the number and percentage of the combinations of the Area Zone and *shots on target*; the number and percentage of the combination of the Area Zone and *goals scored*; and the *total* number and percentage of shots on target and goals scored in relation to the Area Zone, which would also be useful for future reference and comparison with other competitions.

This study focused not only on the detailed distributions of shots on target and goals scored, but also on other features, namely the combination of shooting angles and goal zones. Table 2 simplifies the frequencies of the combination of shots on target and goals scored in relation to the Goal Zone and the angles of shots, which are presented to identify the difference of the goal ratio based on the combination of shooting angles and the Goal Zone. Nine goal zones are combined with 3 angles (L=Left, C=Centre, R=Right) of shots. To avoid any confusion, the combination is arranged as follows, for example, 'L' with 'La' of the Goal Zone signifies that the goals were kicked from left side ('L') toward La-zone, without considering the distance from the shooting position to the goal post. If the combination is L-La, then the combination is considered from the "same angle", whilst combinations like L-Ca and L-Ra, are from "different angles".

TABLE 1. **FREQUENCY OF COMBINATION OF SHOT AREAS, SHOTS ON TARGET AND GOALS SCORED**

Shots made	Goal Zones								
	La	**Lb**	**Lc**	**Ca**	**Cb**	**Cc**	**Ra**	**Rb**	**Rc**
(1) Number of combinations of shot areas - shots on target (blocked goals)	(L4) 1 (L5) 4 (L6) 2 (L7) 4 (L8) 3 (C4) 4 (R3) 1 (R4) 3 (R6) 1 (R8) 4	(L7) 1	(L8) 2 (R8) 1	(L2) 1 (L3) 1 (L4) 1 (L5) 1 (L8) 2 (C2) 1 (C3) 1 (C4) 8 (R1) 1 (R3) 2 (R7) 3 (R8) 6	(L4) 2 (L8) 2 (C4) 1 (R4) 1	(L7) 1 (L8) 1 (C2) 1 (C4) 6 (R3) 1 (R8) 4	(L3) 2 (L4) 1 (L6) 2 (L7) 1 (L8) 2 (C4) 7 (R3) 1 (R4) 3 (R5) 1 (R6) 2 (R7) 3 (R8) 8	(L6) 1 (C2) 1 (C3) 1 (C4) 1 (R5) 1 (R8) 2	(L8) 3 (C4) 1
Frequency of (1)	27 (22.0%)	1 (0.8%)	3 (2.4%)	28 (22.7%)	6 (4.9%)	14 (11.4%)	33 (26.8%)	7 (5.7%)	4 (3.3%)
(2) Number of combination of shot areas - scored goal (Three Penalty-Kicks excluded)	(L2) 1 (L3) 2 (L4) 1 (C2) 2 (C3) 3 (R2) 2 (R3) 2	(L1) 1 (L3) 1 (C1) 2 (R4) 1	(L3) 1 (C1) 1 (C2) 1 (R7) 1	(L1) 1 (L2) 1 (L5) 1 (C1) 3 (C2) 2 (C3) 1 (C4) 1 (R3) 1 (R6) 1	(C2) 2	(L7) 2 (C2) 5 (C4) 1	(L2) 1 (L3) 1 (L5) 1 (L7) 1 (L8) 1 (C1) 2 (C2) 2 (C3) 3 (R3) 1 (R8) 1	(L2) 2 (L6) 1 (C1) 3 (R1) 1 (R2) 1 (R8) 1	(L8) 1 (C2) 1 (R1) 2 (R2) 1 (R3) 1
Frequency of (2)	13 (18.0%)	5 (6.9%)	4 (5.5%)	12 (16.4%)	2 (2.7%)	8 (11.0%)	14 (19.0%)	9 (12.3%)	6 (8.2%)
∑Frequency (3)=(1)+(2)	40 (20.4%)	6 (3.0%)	7 (3.6%)	40 (20.4%)	8 (4.1%)	22 (11.2%)	47 (24.0%)	16 (8.2%)	10 (5.1%)

In terms of (a) from Table 2, the frequencies of some combinations of same angles were higher than the other combinations, for instance, R-Ra (18 shots on target), L-La (14 shots on target), and C-Ca (10 shots on target). However, in terms of (b) the patterns were not consistent. Nevertheless, 7 goals were scored in the combination of C-Ca, followed by 6 goals from C-Cc and 4 goals from L-La and R-Rc. In relation to (c), the frequencies of some of the combinations of *same angles* were higher than the other combinations, for instance, R- Ra (20), L-La (18), C-Ca (17), C-Cc (13). Combinations of *different angles* were identified as R-Ca (14), C-Ra (14) and R-La (13).

TABLE 2. **FREQUENCY OF SHOTS ON TARGET AND GOALS SCORED AND ANGLES OF SHOTS IN RELATION TO GOAL ZONE**

Shots made	Low Zone			Middle Zone			High Zone		
	La	**Ca**	**Ra**	**Lb**	**Cb**	**Rb**	**Lc**	**Cc**	**Rc**
(a) Frequency of shots on target and the angles of shots	L 14 (11.4%)	L 6 (4.9%)	L 8 (6.5%)	L 1 (0.8%)	L 4 (3.3%)	L 1 (0.8%)	L 2 (1.6%)	L 2 (1.6%)	L 3 (2.4%)
	C 4 (3.3%)	C 10 (8.1%)	C 7 (5.7%)	C 0 (0%)	C 1 (0.8%)	C 3 (2.4%)	C 0 (0%)	C 7 (5.7%)	C 1 (0.8%)
	R 9 (7.3%)	R 12 (9.8%)	R 18 (14.6%)	R 0 (0%)	R 1 (0.8%)	R 3 (2.4%)	R 1 (0.8%)	R 5 (4.1%)	R 0 (0%)
(b) Frequency of scored goals and the angles of shots (Three Penalty-Kicks excluded)	L 4 (5.5%)	L 3 (4.1%)	L 5 (6.8%)	L 2 (2.7%)	L 0 (0%)	L 3 (4.1%)	L 1 (1.4%)	L 2 (2.7%)	L 1 (1.4%)
	C 5 (6.8%)	C 7 (9.6%)	C 7 (9.6%)	C 2 (2.7%)	C 2 (2.7%)	C 3 (4.1%)	C 2 (2.7%)	C 6 (8.2%)	C 1 (1.4%)
	R 4 (5.5%)	R 2 (2.7%)	R 2 (2.7%)	R 1 (1.4%)	R 0 (0%)	R 3 (4.1%)	R 1 (1.4%)	R 0 (0%)	R 4 (5.5%)
(c)= (a)+(b)	L 18 (9.2%)	L 9 (4.6%)	L 13 (6.6%)	L 3 (1.5%)	L 4 (2.0%)	L 4 (2.0%)	L 3 (1.5%)	L 4 (2.0%)	L 4 (2.0%)
	C 9 (4.6%)	C 17 (8.7%)	C 14 (7.1%)	C 2 (1.0%)	C 3 (1.5%)	C 6 (3.1%)	C 2 (1.0%)	C 13 (6.6%)	C 2 (1.0%)
	R 13 (6.6%)	R 14 (7.1%)	R 20 (10.2%)	R 1 (0.5%)	R 1 (0.5%)	R 6 (3.1%)	R 2 (1.0%)	R 5 (2.6%)	R 4 (2.0%)

L = Left angle C = Centre angle R = Right angle

Table 2 reorganises the frequencies according to **the low, the middle and the high zones** of the Goal Zone. Of the 196 shots, 20 shots on target and goals scored were taken from the *right side* toward the Goal Zone, 'Ra' (10.2%, R-Ra combination). There were 18 deliveries from the *left side* towards 'La' (9.2%, L-La combination), followed by 17 (8.7%) of the C-Ca combination, 14 (7.1%) for each of the R-Ca and C-Ra combinations and 13 (6.6%) for each of the R-La the C-Cc combinations. Regarding the *low zones* (La, Ca, Ra) of the Goal Zone, 72 shots on target and goals scored were from different angles, whilst 55 were from the same angles. In the *middle zones* (Lb, Cb, Rb) of the Goal Zone, 18 shots on target and goals scored were from different angles, whilst 12 were from the same angles. In relation to the

high zone (Lc, Cc, Rc) of the Goal Zone, 20 shots on target and goals scored were from the same angles and 19 were from different angles. In the case of the *low zones*, there was a

statistically significant difference in shots on target and goals scored from the different angles compared to those from the same angles (χ^2=377.59; p<0.001).

Regarding the **shots on target** alone, 18 (14.6%) shots were produced from the right side toward Ra (R-Ra combination) and was followed by 14 (11.4%) shots with the L-La combination, 12 (9.8%) shots with the R-Ca combination, 10 (8.1%) shots with the C-Ca combination, 9 (7.3%) shots with the R-La combination, 8 (6.5%) shots with the L-Ra combination and 7 (5.7%) shots with each of the C-Cc and C-Ra combination. In the combinations from different angles, there were 46 shots on target to the *low zones* (La, Ca, Ra) of the Goal Zone with 42 shots on target from the same angles. For the *middle zones* (Lb, Cb, Rb) of the Goal Zone, 9 shots on target were from different angles and 5 were from the same angles. Further, for the *high zones* (Lc, Cc, Rc) of the Goal Zone, 12 shots on target were from different angles and 9 were from the same angles. In terms of the low zones, there was a statistically significant difference in shots on target from different angles compared to those from the same angles (χ^2=228.99; p<0.001).

In relation to the **goals scored**, 7 goals were scored with the C-Ca (9.6%) and the C-Ra combination (9.6%), 6 goals with the C-Cc combination (8.2%), followed by 5 goals with the C-La (6.8%) and the L-Ra (6.8%) combination, 4 goals with each of the L-La (5.5%), the R- La (5.5%) and the R-Rc (5.5%) combinations. Goals scored from different angles have a distinctive pattern, which could characterise the angles attackers tried to shoot from and the ratio of success. Statistics revealed that 26 goals were scored using different angles, whilst 13 goals were scored using the same angles in relation to the low zones (La, Ca, and Ra) of the Goal Zone. In terms of the middle zone (Lb, Cb and Rb) of the Goal Zone, 9 goals were from different angles and 7 goals were from the same angles. In addition, 11 goals were from the same angles and 7 goals were from different angles in relation to the high zones (Lc, Cc and Rc) of the Goal Zone. In the case of the low zones, there was a statistically significant difference in goals scored from the different angles compared to those from same angles (χ^2=146.00; p<0.001).

DISCUSSION AND PRACTICAL APPLICATION

This study conducted a statistical analysis on the pattern of shots on target and goals scored during the 2012-UEFA European Championship to understand the scientific reality of the game and to construe some meaningful implications for goalkeeper coaching and training. During the European Championship, whilst 196 shootings were attempted, 73 shots (37%) resulted in goals scored and 123 (63%) shots were blocked. Only 8 goals (11%) were scored from the outskirts of the Area Zone. Understandably, due to the distance, the probability of goals from the outskirts of the Area Zone would decrease significantly. However, 65 goals (89%) out of total 73 goals recorded during the Championship were scored within the goal and penalty area. The match analysis of the 2004-UEFA European Championship in Portugal showed similar patterns with those of the findings of this study, where 76.6% of total goals were scored from the goal and the penalty area during the soccer game (Yiannakos & Armatas, 2006). These results are also similar to those reported by Romero *et al*. (1997) for the 1996-UEFA European Football Championship. Regarding research on the 2012-UEFA

European Championship (Henceforth the Championship), Michailidis *et al*. (2013) and Mitrotasios and Armatas (2014) reported that 92.2% and over 90% of total goals

respectively were scored in the goal and penalty area. Different methods of data coding and analysis seem to cause some statistical discrepancies.

In relation to the Goal Zone, 88 shots on target (71.5%) out of a total of 123 shots were targeted on the low zones (La, Ca, Ra) of the Goal Zone during the Championship, while 39 goals (53.4%) out of total 73 scored were also made in the low zones of the Goal Zone. In total, goalkeepers had to deal with 127 shootings (64.7%) out of 196 toward the low zones of the Goal Zone. The findings indicate that most of the shots on target and goals of the Championship were completed from the goal and penalty area, into the low zones of the Goal Zone. Sainz de Baranda *et al*. (2008) reported a similar tendency in the 2002-FIFA World Cup. This implies that football players, especially goalkeepers, and coaches in training sessions have to familiarise themselves with the specific scoring possibilities within these areas (Michailidis *et al*., 2013). In particular, Hoff (2005) and Sainz de Baranda *et al*. (2008) emphasised that strength of the lower body and arm span of a goalkeeper determine the efficacy of his/her physical actions, such as the dive (a parry or a fly). To prepare for situations of maximum intensity, goalkeeper-training sessions need to focus also on actually practising to deal with shootings targeting the low zones of the Goal Zone from close distances.

Whilst some previous studies investigated physical actions of goalkeepers, such as save, foot control, dive, jump, displacement, etc. (Sainz de Baranda *et al*., 2008; Spratford *et al*., 2009; Paz-Franco *et al*., 2014), this study tried to identify the fundamental facts that are relevant to the actions and training of a goalkeeper, which have not been fully covered in previous literature. During the Championship, a total of 72 shots on target and goals were made from different angles, whilst 55 were from the same angles in relation to the low zones of the Goal Zone, with the difference being statistically significant (χ^2=377.59; $p<0.001$). With regard to the shots on target, the low zones of the Goal Zone and the angles, 46 shots on target were from different angles and 42 shots were from the same angles. It means that goalkeepers had successfully blocked shots from various combinations. However, 26 goals were scored from different angles and 13 goals were from the same angles in relation to the low zone of the Goal Zone, which produced a statistically significant difference between these scores (χ^2=146.00; $p<0.001$).

In the critical moments during the Championship, the goals scored from different angles would be identified as being more effective for offensive players and more vulnerable for goalkeepers based on the findings. In this respect, Philippaerts *et al.* (2006) reported that lateral saves by a goalkeeper are determined by their technical skill to deal with lower balls and their body strength. Furthermore, many scholars (Hughes, 1996; McGarry & Franks, 2000; Savelsbergh *et al*., 2002; Hughes & Franks, 2004; Paz-Franco *et al*., 2014), have reported that a goalkeeper needs the capacity of circumstantial judgement, adequate body movements and effective cooperative defence to deal with critical moments during the game.

Soccer is a team sport, which needs a holistic approach when training the single individual as an important asset and the team as an effective mechanism. Paz-Franco *et al*. (2014) explained that team sports have to adapt to changing environments, which would be intrinsic

in the nature of team sports like futsal (football indoors) and soccer. Generally, elite soccer

players have to have high aerobic endurance fitness to cope with the intense nature of the modern game (McMillan *et al*., 2005). In particular, goalkeepers need not only physical strength, but also the motor skill and some cognitive components, such as understanding the soccer game and reasonable decision-making abilities (Lee *et al*., 2007; Paz-Franco *et al*., 2014). Proper circumstantial judgement by and the technique of a goalkeeper for physical responses, need to be internalised naturally through constant training and education, which could influence his/her game in different ways. According to Knapp (1963), whilst technique means the ability and skill to execute motor components, decision-making in sporting environments represents a reasonable choice of technique in changing circumstances, in which his/her action is located. Decision-making are especially crucial in determining game results and the performance of individual players (Thomas, 1994; Paull & Glencross, 1997; Blomqvist *et al*., 2001; Araujo *et al*., 2006).

In a defensive situation, the main duty of a goalkeeper would be clearing a ball outside the goalposts and blocking or holding a ball so that it cannot pass over the goal line. In other words, during the Championship attackers shot balls aiming at lower areas than the knees of goalkeepers. From a relatively close distance, low-flying balls or balls aiming at low zones could be more troublesome than others from the perspective of a goalkeeper. Sainz de Baranda *et al*. (2008) and Spratford *et al*. (2009) stress that shots from a close distance should dominate in training sessions for goalkeepers based on their findings and that previously reported in the literature. Yiannakos and Armatas (2006) argue that the physical abilities and stamina of players have to be improved to dominate the games.

For these reasons, consistent training directed at improving body strength, accurate basic posture, positions and movements in these situations are needed (Hoff, 2005; Philippaerts *et al*., 2006; Yiannakos & Armatas, 2006; Sainz de Baranda *et al*., 2008), which could also enable goalkeepers to exercise the right decision-making in actual game situations (Thomas, 1994; Paull & Glencross, 1997; Blomqvist *et al*., 2001; Araujo *et al*., 2006). The specific training methods, about posture and position for low-flying balls or balls flying toward low zones from a close distance and at different angles, have to be developed and performed to improve the capacity of the physical skills of goalkeepers and their effective decision-making. Furthermore, the presentation of training sessions should include constant practices aiming for proper adaptation in different circumstances. Goalkeepers have to master basic skills from the early stage of their careers, so that effective decision-making of goalkeepers in various situations can be nurtured.

From the perspective of a goalkeeper, he/she would need the physical capacity for quick movements and bodily instincts to handle shots from different angles from a close distance, which happens in few seconds. However, these abilities cannot be established properly in a short period. Therefore, there have been several reports of the benefits of power endurance, motor skills and cognitive training at youth stages to develop the competence of players (Winkler, 2001; Reilly, 2005; Balčiūnas *et al*., 2006). In this respect, methodical training programmes about basic posture as a preparation and lateral saves, like dive, are constantly practised starting from youth teams to enhance the physical and mental competencies of goalkeepers.

Finally, setting unavoidable situations aside, cooperative defence strategies could reduce attacking options for the opponent (Yoon *et al*., 2012). It means that goalkeepers could increase the possibility of avoiding critical attacking moments from the opponent, such as

low-flying balls from inside the penalty area. Although the critical situation cannot be avoided even in cooperative defence, a goalkeeper could respond stably due to the increased predictability resulting from cooperative defence. This can reduce the attacking options of the opponent. In this respect, goalkeeper training to cope with various situations has to be developed in relation to cooperative defence strategies (Sainz de Baranda *et al*., 2008; Yoon *et al*., 2012). This has to be practised constantly and repeatedly so that goalkeepers can engage with quick decision-making and effective motor performance.

CONCLUSIONS

Goalkeepers perform crucial roles in characterising soccer games by their momentary decision-making and motor skills, which have to be inculcated by constant training of basic defensive tactics and practising to adapt to various circumstances. For the fundamental orientation towards goalkeeper coaching and training, this study analysed one major soccer tournament, the 2012-European Championship, to identify meaningful implications in relation to shots on target, goals scored and the related variables. The results showed that 88 shots on target (72%) out of a total of 123 and 39 goals scored (53.4%) out of a total of 73 were aimed at the low zones of the Goal Zone. Goalkeepers blocked 80 shots (65%) from outside the penalty area, whilst 65 goals (89%) were made inside the goal and penalty area, which implies that close-range shots would be more critical in predicting the direction and result of the game than any other factors.

With regard to the combination of the Goal Zone and shooting angles, 72 shots on target and goals scored were from different angles, while 55 shots were from the same angles in relation to the low zones. Significantly, 26 goals were scored through different angles and 13 goals were from the same angles when targeting the low zones of the Goal Zone. Given these results, it can be inferred that attackers are prone to seek their scoring opportunities by aiming their shots on the low zones of the Goal Zone. In addition, goalkeepers in various situations could be vulnerable to shots aimed at the low zones from different angles. In this respect, systemic training methods are required to improve the ability of goalkeepers to deal with the critical situations occurring during soccer games. Based on the findings of this study, practitioners and researchers need to develop goalkeeper-training programmes, which should especially target low-flying balls from a close-distance, along with developing physical strength and decision-making abilities, starting from youth stages. Further research about these topics for different soccer competitions will strengthen and enrich the rationale of the necessity of specific training and systemic training methods for goalkeepers.

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CHANGES IN INSULIN RESISTANCE AND ADIPOKINES IN OBESE WOMEN FOLLOWING A 12-WEEK PROGRAMME OF COMBINED EXERCISE TRAINING

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ABSTRACT

This study examined the effect of 12 weeks of combined exercise training on levels of leptin, adiponectin and blood lipids in obese women. The subjects (N=20) were assigned randomly to the combined exercise training (resistance and aerobics) group (CEG: n=10) or the control group (CG: n=10). Exercise sessions took place three times weekly for 12 weeks. The combined exercise training was composed of walking on an air-board and resistance exercise at 30 to 50% of the one repetition maximum. Subjects in the CG did not participate in any exercise programme. A main effect of participation was observed for body weight, percentage body fat and glucose ($p<0.05$). An interaction was detected between time and group on body weight, percentage body fat, triglycerides, total cholesterol, leptin and adiponectin ($p<0.05$). However, no significant differences were observed in the assessment of the homeostasis model estimate of insulin resistance, insulin, high-density lipoprotein cholesterol or low-density lipoprotein cholesterol. These results indicate that the combined exercise training programme improved insulin-sensitising cytokines and blood lipids in the obese women.

Key words*:* Insulin resistance; Adiponectin; Combined exercise programme; Obese women; Leptin.

INTRODUCTION

Obesity and insulin resistance are clinical markers for the early detection of cardiovascular disease and Type-2 diabetes (Gale, 2008; Slentz *et al*., 2009). Adipose tissue functions as an endocrine organ, in addition to its role of fuel storage, thermal insulation, mechanical protection and release of biologically active and diverse cytokines, termed adipokines, such as leptin and adiponectin (Pajvani *et al*., 2003; Kershaw & Flier, 2004). Leptin and adiponectin are adipokines that are strongly associated with obesity and insulin resistance (Pittas *et al*., 2004; Dyck *et al*., 2006). However, the response of adipokines and insulin resistance to exercise training has not been clearly defined.

Leptin is regulated by fat storage status, with larger adipocytes containing more leptin than smaller adipocytes in the same individual (Sihna & Caro, 1998). It has been suggested that

nutrition-related control of leptin is regulated in part by insulin. Leptin expression after an elevation in insulin in response to eating and a decline in leptin levels following the reduction in insulin during fasting have been reported (Saladin *et al*., 1995; Boden *et al*., 1996). Adiponectin has direct and indirect functions, primarily related to endothelial function and promotion of insulin sensitivity (Berg & Scherer, 2005).

Exercise training is a demonstrated method to reduce metabolic risks by increasing insulin sensitivity, decreasing weight and improving cardiovascular fitness (Duscha *et al*., 2005; Church *et al*., 2007). In addition, exercise training may affect leptin (Kraemer *et al*., 2002) and adiponectin (Simpson & Singh, 2008) levels. The leptin response is diverse according to the duration of exercise training. Insulin sensitivity increases without a change in leptin after short-term (<12 weeks) training periods (Houmard *et al*., 2000) and leptin concentration does not change despite increased cardiopulmonary function (Kraemer *et al*., 1999). In contrast, leptin concentration decreases with long-term (≥12 weeks) training. Hickey *et al*. (1997) reported that leptin concentrations decrease after 12 weeks of aerobic exercise in women. Okazaki *et al*. (1999) reported decreased leptin concentrations and weight after 12 weeks of aerobic exercise. Resistance exercise increases lean body mass and basal metabolic rate and leptin concentration only decreases in those who lose weight after resistance training (Ryan *et al*., 2000). Many differences have been reported regarding adiponectin and exercise duration and the type of programme applied. Adiponectin concentration decreases after acute exercise, but adiponectin mRNA increases in skeletal muscle after exercise training (Kraemer & Castracane, 2007).

PURPOSE OF THE STUDY

The effects on adipokines differ according to type, intensity, frequency and time of exercise, but most studies used aerobic exercise and few studies have investigated different programmes with resistance exercise (Golbidi & Laher, 2014). In particular, studies that have investigated combined programmes of aerobic and resistance exercise are very limited. Therefore, it is important to define clearly the leptin and adiponectin responses to combined exercise training. The purpose of this study was to examine the effects of a 12-week combined exercise training programme on body composition, blood lipids, insulin resistance, leptin and adiponectin in obese women.

METHODOLOGY

Participants

Twenty untrained obese women (age range of 20 to 55 years; 45.3±9.1) volunteered to participate in this study. The G*Power programme was used to calculate the effect size and statistical power. Based on the 2×2 repeated-measures design and an anticipated statistical power of 0.85 with an effect size 0.3, 20 subjects were necessary (G-power program 3.12, Dusseldorf, Germany). Informed and written consent was obtained from all participants prior to starting the study. The Institutional Review Board of the Institute of Sports Science of Dongguk University approved this study. Criteria for obesity were Body Mass Index (BMI)
>25kg/m^2 (Asia-Pacific BMI cut-off value) (Weisell, 2002), and percentage (%) body fat >30.

Subjects completed a medical history and a questionnaire on exercise habits to determine their eligibility (<30min/day of exercise) to participating in the training programme. None of the subjects used oral contraceptives or medications known to affect body composition at the time of enrolment in the study. Smoking, alcohol and drug use were not controlled for in the subjects. All subjects were instructed to maintain their typical diet and activity patterns throughout the study, and compliance with this instruction was assessed by food-

frequency and physical activity questionnaires administered at the beginning and end of the study. However, neither menstrual cycles nor the contraceptive information of the subjects were taken into account.

Research design

The subjects were assigned randomly to 1 of 2 groups: the combined exercise training (walking and circuit resistance exercise) group (CEG, n=10) or the control group (CG, n=10). Subjects in the CG did not participate in any exercise program. All variables of the pre- and post-training were compared between the groups after 12 weeks.

Anthropometric measures

Height and weight were measured to the nearest 0.1cm and 0.1kg respectively, using the Inbody 720 instrument (Biospace, Seoul, Korea). The BMI was calculated as kg/m^2. Percentage body fat was measured using the Inbody 720. The waist-hip ratio was calculated as waist circumference divided by hip circumference and measured to the nearest 0.1cm using a standard measuring tape.

Blood assays

Blood samples (10ml) were collected from the left anterior vein into Vacutainer EDTA tubes (Becton-Dickinson, Parsippany, NJ, USA), during the morning after a 12-hour fast. After 10 minutes at room temperature, the blood samples were centrifuged (3000rpm) and the plasma was frozen at −70°C. The plasma samples were packed in ice and sent to the NEODIN Medical Institute (Seoul, Korea).

Serum triglyceride (TG) and total cholesterol (TC) concentrations were determined by enzymatic methods using a Technicron RA-500 analyser (Bayer, Tarrytown, NY, USA). The high-density lipoprotein-cholesterol (HDL-C) levels were assessed after precipitating low- density lipoprotein-cholesterol (LDL-C) in the infranatant using the heparin-manganese chloride method (Burstein & Sammaille, 1960). Plasma glucose was measured using an enzymatic technique of Richterich and Dauwalder (1971). The Homeostasis Model Assessment estimate of Insulin Resistance (HOMA-IR) was calculated from fasting insulin (IF) and fasting glucose (GF), as follows: HOMA-IR=(IF × GF)/22.5 (IF in μU/mL and GF in mmol/L) (Yeckel *et al*., 2004). Specific commercially available enzyme immuno-assay kits (Millipore, St. Charles, MO, USA) were used to measure plasma leptin and adiponectin levels.

Exercise training programme

Five minutes of voluntary stretching before and after exercise was recommended for all participants in the combined-exercise training group. Subjects in the training group

participated in a 30-minute circuit of resistance exercises, which consisted of pecflys, leg press, shoulder press, squats, upright row, biceps and triceps, abdominals and lower back, inner and outer thighs, rotary torso, gluteus and hamstrings, chest press, keg curl and walking in place on an Air-board (Equbic Air Board, Seoul, Korea). Walking in place was performed for 1 minute after each resistance exercise.

The circuit of resistance exercises consisted of 1 set of 30 repetitions at 30 to 50% of 1 repetition maximum (1RM) using a hydraulic machine (Henley Healthcare, Sugar Land, TX, USA) (Takeshima *et al.*, 2004). The subjects maintained an intensity of 60 to 80% of their predicted maximum heart rate (Londeree & Moeschberger, 1984), while walking in place. Intensity was monitored throughout the exercise routine using the Polar real-time system (S810; Polar Inc., Kempele, Finland). Exercise intensity was reset (1RM and target heart rate) every 4 weeks. A trained professional supervised all exercise sessions. The exercise routine was the same throughout the 12-week training period.

Analysis of data

Descriptive data are presented as means and standard deviations. One-way analysis of variance (ANOVA) was used to examine differences in the characteristics of subjects between groups at the baseline measurement. Repeated-measures ANOVA was used to analyse the effects of the intervention on HOMA-IR, leptin, adiponectin and other blood parameters. A $p<0.05$ was considered significant and the SPSS version 17.0 software (SPSS, Inc., Chicago, IL, USA), was used for all analyses.

RESULTS

At the baseline measurement, there were no differences between the groups for all variables (Table 1). Therefore, the subjects in the 2 groups were similar in age, BMI, body weight and percentage body fat.

TABLE 1. **CHARACTERISTICS OF PARTICIPANTS**

Characteristics	**Exercise group** (n=10) Mean±SD	**Control group** (n=10) Mean±SD	**p-Value**
Age (years)	46.7±9.6	44.8±8.4	0.643
Height (cm)	160.1±6.5	157.0±3.1	0.203
BMI (k/gm^2)	27.4±2.9	28.2±3.3	0.565

Note: No differences between groups ($p<0.05$) SD=Standard Deviation BMI=Body Mass Index

Table 2 shows the changes in body weight, as well as the levels of percentage body fat, TG, TC, HDL-C, LDL-C, insulin, glucose, HOMA-IR, leptin and adiponectin after the 12-week intervention. A significant ($p<0.05$) interaction effect was detected between time and group on body weight, percentage body fat, TG, TC, leptin and adiponectin. However, no significant differences were observed for HOMA-IR, insulin, HDL-C and LDL-C.

TABLE 2. **BODY COMPOSITION, BLOOD LIPIDS, LEPTIN, ADIPONECTIN AND HOMA-IR BEFORE AND AFTER 12-WEEK TRAINING PERIOD**

Variables	**Exercise Group** Baseline	After training	**Control Group** Baseline	After 2 weeks	**Interaction** (Time×Group) F	p-Value
Weight (kg)	70.3±9.20	66.8±8.80	69.7±8.70	69.8±8.80	30.524	0.001*
CV	0.13	0.13	0.12	0.13		

Body fat (%)	37.7±4.90	34.3±5.90	36.7±3.60	37.1±3.60	25.645	0.001*
CV	0.13	0.17	0.10	0.10		
TG (mg/dL)	104.8±37.60	88.5±34.20	122.0±46.60	138.4±37.60	14.102	0.001*
CV	0.36	0.39	0.38	0.27		
TC (mg/dL)	179.0±23.50	171.8±24.80	169.9±27.20	174.2±28.50	6.779	0.018*
CV	0.13	0.14	0.16	0.16		
HDL-C (mg/dL)	51.2±8.40	49.7±8.80	49.6±8.70	49.9±11.30	0.218	0.646
CV	0.16	0.18	0.18	0.23		
LDL-C (mg/dL)	100.1±21.40	102.6±19.30	102.1±24.70	99.1±26.30	0.757	0.396
CV	0.21	0.19	0.24	0.27		
Glucose (mg/dL)	89.9±8.40	77.9±11.30	91.4±11.70	88.4±11.50	4.001	0.061
CV	0.09	0.15	0.13	0.13		
Insulin (µU/mL)	7.67±4.86	5.74±1.17	5.94±2.50	11.3±13.41	2.747	0.115
CV	0.63	0.20	0.42	1.19		
HOMA-IR	1.69±0.99	1.08±0.19	1.34±0.58	2.73±3.86	2.651	0.121
CV	0.59	0.18	0.43	1.41		
Leptin (ng/mL)	14.4±7.70	11.8±6.30	13.3±5.90	17.8±10.50	9.401	0.007*
CV	0.53	0.53	0.44	0.59		
Adiponectin (µg/mL)	9.20±2.36	10.06±2.41	7.75±1.78	7.35±1.62	7.705	0.012*
CV	0.26	0.24	0.23	0.22		

TG= riglycerides TC=Total Cholesterol HDL-C=High density Lipoprotein Cholesterol LDL-C=Low density Lipoprotein Cholesterol HOMA-IR=Homeostasis Model Assessment estimate of Insulin Resistance
*p=<0.05 CV=Coefficient of Variation

DISCUSSION

The main finding of the current study was that 12 weeks of combined exercise training improved insulin sensitising cytokines, including leptin and adiponectin, in obese women. In addition, body weight, percentage body fat, TG and total TC levels improved after the intervention.

The effects of exercise training on lipid profiles vary. Hansen *et al*. (2009) reported that endurance exercise training reduces LDL-cholesterol concentrations in obese patients with Type-2 diabetes. In contrast, Taghian *et al*. (2014) found that 12 weeks of aerobic exercise training did not affect LDL in obese women. In addition, several other training studies have reported decreases in fasting TG concentrations (Paoli *et al*., 2013; Neves *et al*., 2014) and

increases in HDL-C levels (Cho *et al*., 2014; Zapata-Lamana *et al*., 2015), with exercise training. In this study, a reduction in TG and TC after a 12-week intervention was found, suggesting that the type of exercise training can change blood lipid results.

No significant differences were found for GF or insulin levels between the two groups after the intervention period. Previous studies have suggested that physical activity improves glucose tolerance and insulin sensitivity (Tessier *et al*., 2000; Denton *et al*., 2004). A decrease in glucose tolerance often occurs with increasing age. This impairment in glucose

metabolism is due in part to an increase in insulin resistance. The increased insulin resistance may be the result of a decrease in physical activity and the resulting increase in adiposity that often occurs with age (Kohrt *et al*., 1993). However, according to the results of this study, HOMA- IR and insulin did not differ. Therefore, although the combined exercise programme affected adipocytokines and body composition, the precise relationship between exercise training and insulin resistance remains unclear.

In this study, a significant decline in leptin levels over time was observed in the training group. In addition, adiponectin tended to increase after the combined exercise training. Lower leptin levels are associated with reduced total cholesterol and triglyceride levels independent of improved glucose control (Halle *et al*., 1999; Kraemer *et al*., 2002). One study suggested that exercise training-induced reductions in leptin levels might be attributable to alterations in energy balance and gluco-regulatory factors, including improved insulin sensitivity and lipid metabolism (Kraemer *et al*., 2002). The effects of exercise training on leptin have been related to changes in body weight and/or percentage body fat in previous studies (Hayase *et al*., 2002; Giannopoulou *et al*., 2005; Arikawa *et al*., 2011). In addition, the results also showed a decrease in leptin levels with decreasing body weight, percentage body fat, triglycerides and total cholesterol after the exercise intervention. These results suggest that exercise training could be an effective method for improving problems associated with obesity, such as metabolic disorders.

Adiponectin plays an important role in controlling metabolic dysfunction and restoring normal levels. It might contribute to better health outcomes by improving glucose homeostasis, insulin sensitivity and fatty acid oxidation. Some studies have suggested that aerobic and resistance exercise training improves plasma adiponectin levels (Fatouros *et al*., 2005; Giannopoulou *et al*., 2005; Marcell *et al*., 2005). However, other studies have reported different results. Hara *et al*. (2005) determined that an exercise intervention was ineffective in changing adiponectin concentrations in obese subjects. They reported that improvements in body composition are more important than exercise training for increasing adiponectin levels. The results of the present study indicated that the combined exercise training improved body weight and percentage body fat, as well as increased adiponectin after combined exercise training.

CONCLUSION

The 12 weeks of combined exercise training had beneficial effects on body composition, triglycerides, total cholesterol, leptin and adiponectin in the group of obese women who participated in this study. Accordingly, the results suggest that combined exercise training could positively affect adipokines and metabolic risk factors in obese women.

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DOES EMG ACTIVATION DIFFER AMONG FATIGUE-RESISTANT LEG MUSCLES DURING DYNAMIC WHOLE-BODY VIBRATION?

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ABSTRACT

The purpose of this study was to determine the effects of dynamic whole-body vibration (WBV) stimuli on the electromyographic (EMG) responses of different fatigue-resistant leg muscles. The participants (N=32) were divided into two groups according to the Fatigue Index value [Group I: Less Fatigue Resistant (LFR), n=17; Group II: More Fatigue Resistant (MFR), n=15]. The repeated EMG activities of four leg muscles [rectus femoris, biceps femoris, vastus lateralis and vastus medialis] were analysed during WBV stimulation. The data were analysed using PASW/SPSS Statistics 18.0 and the significance level was set at $p<0.05$. The results revealed that the vibration frequency, amplitude and group (MFR and LFR) had a significant effect ($p<0.001$) on the EMG response. Dynamic WBV stimuli performed at different frequencies (30Hz, 35Hz and 40Hz) and amplitudes (2mm and 4mm) resulted in significantly increased lower-body muscular activation. However, the LFR group exhibited a significantly higher percentage increase in EMG activation at higher frequencies (max 40Hz) and amplitudes (4mm) ($p\leq0.001$). The results could be useful for the optimal prescription of vibration exercise and can guide the development of training and rehabilitation programmes.

Key words: Fatigue; Fatigue resistance; Isokinetic; Rehabilitation; Muscle activation; Electromyography.

INTRODUCTION

Previous studies of whole-body vibration (WBV) exercise indicate that this form of exercise increases muscle strength (Bosco *et al.*,1999; Torvinen *et al.*, 2002; Delecluse *et al.*, 2003; De Ruiter *et al.*, 2003; Roelants *et al.*, 2004; Cardinale & Wakeling, 2005; Luo *et al.*, 2005; Osawa *et al.*, 2013; Yoosefinejad *et al.*, 2014), enhances the development of movement speed (Cheung *et al.*, 2007; Lamont *et al.*, 2009), improves jumping ability (Lamont *et al.*, 2009), improves balance and flexibility (Cochrane & Stannard, 2005; Cheung *et al.*, 2007), and positively affect metabolic-hormonal responses in males (Bosco *et al.*, 2000; Kerschan- Schindl *et al.*, 2001; Rittweger *et al.*, 2002; Kvorning *et al.*, 2006). Additionally, WBV stimuli have a favourable effect on the elderly and on individuals with clinical complaints (Schuhfried *et al.*, 2005; Bogaerts *et al.*, 2009; Johnson *et al.*, 2010; Ochi *et al.*, 2015; Orr, 2015). WBV can also be used for therapeutic purposes, such as the prevention of bone loss during rehabilitation (Ezenwa *et al.*, 2008), treatment of spinal cord injuries (Ness & Field- Fote, 2009) and the treatment of multiple sclerosis (Jackson *et al.*, 2008).

WBV exercise has become increasingly popular and has sparked considerable interest, particularly among elite athletes, who perform WBV exercise extensively to increase muscular performance (Bosco *et al.*, 1999; Cochrane & Stannard, 2005; Roelants *et al.*, 2006; Abercromby *et al.*, 2007; Di Giminiani *et al.*, 2009; Di Giminiani *et al.*, 2010; Pollock *et al.*, 2010). Increases in muscle performance produced by WBV are theorised to result from the elicitation of involuntary reflex contractions by WBV (Mester *et al.*, 1999) via the tonic vibration reflex (TVR) (Hagbarth, 1967; Burke *et al.*, 1976). The TVR is a spinal reflex that responds to changes in muscle length caused by frequency and/or

amplitude displacements generated by the WBV platform. These reflexive contractions might augment voluntary skeletal muscle activation, which results in increased muscle performance (Cardinale & Lim, 2003; Roelants *et al*., 2006).

Krol *et al*. (2011) investigated the muscular activation responses of the *vastus medialis* (VM) and *vastus lateralis* (VL) muscles to different frequencies (20Hz, 40Hz and 60Hz) and amplitudes (2mm and 4 mm). Muscular activation values increased in these muscles due to increases in both the frequency and the amplitude. In another study by Roelants *et al.* (2006) involving three different squat exercises, the maximal voluntary contraction values of leg muscles showed a muscular activation response ranging from 12.6 to 82.4%. Neuromuscular responses of the VL muscle during WBV were explored in a previous study and different frequencies resulted in different muscular activation responses (Cardinale & Lim, 2003).

Hazell *et al*. (2007) investigated the effects of WBV on the electromyographic (EMG) activities of the upper-body (*biceps brachii* and *triceps brachii*) and lower-body muscles [VL and *biceps femoris* (BF)] during isometric semi-squats, dynamic leg squats and static and dynamic bilateral bicep curls. The results of this study demonstrated that: WBV increased muscle activity by 2.9 to 6.7% in the VL and 0.8 to 1.2% in the BF in a static semi-squat; WBV increased muscle activity in the VL by 3.7 to 8.7% and in the BF by 0.4 to 2.0% during dynamic squatting; WBV had no effect on *biceps brachii* EMG activity, but did increase *triceps brachii* EMG activity by 0.3 to 0.7% in a static biceps curl; WBV increased *biceps brachii* EMG activity by 0.6 to 0.8% and *triceps brachii* EMG activity by 0.2 to 1.0% during dynamic bicep curls; and a higher WBV amplitude (4mm) and higher frequencies (35Hz, 40Hz or 45Hz) resulted in the greatest increases in EMG activities (Hazell *et al*., 2007).

Although most of these studies focused on leg muscles, no studies have investigated combinations of these parameters that might allow WBV activation to produce the highest possible level of neuromuscular activity in the leg muscles. The limitations of previous studies include a lack of knowledge of biomechanical variables that determine the vibration load (vibration frequency, vibration amplitude and joint angle) and exercise parameters (side alternating or synchronous vibration platform devices, acute vs. chronic effects, exercise position). These parameters and variables have not been investigated previously. Despite the above-mentioned benefits of vibration stimuli, no effective physical exercise protocol has yet been established for WBV exercises. Additionally, sport that require long or short exercise duration intrinsically require high levels of sensitivity to fatigue and/or recruitment of fatigue-resistant leg muscle groups. No previous studies have investigated the effects of WBV on more fatigue-resistant (MFR) and less fatigue-resistant (LFR) leg muscles. A common conclusion of the previous studies on this topic has been the need to develop an effective personalised vibration training procedure and physical exercise protocol.

PURPOSE OF RESEARCH AND HYPOTHESES

The present study investigated the effects of WBV stimuli at low (2mm), high (4mm) amplitudes and various frequencies (30Hz, 35Hz and 40Hz) on the LFR and MFR groups during dynamic leg squats. It was hypothesised that WBV stimuli applied during dynamic leg squats would cause:

(1) EMG activities of LFR and MFR muscle groups to significantly increase at all frequencies compared with those caused by non-vibrating stimuli;
(2) EMG activity of the LFR leg muscle group to be significantly higher at all frequencies and amplitudes than that of the MFR leg muscle group;
(3) EMG activation of LFR leg muscles to increase by increasing the WBV frequency;
(4) EMG activation of MFR leg muscles to decrease by increasing the WBV frequency; and
(5) EMG activation of MFR and LFR leg muscles to increase by increasing the WBV amplitude.

METHODOLOGY

The University of Osman Gazi Human Research Ethics Board approved this study, and subjects provided their informed written consent prior to participation.

Sample

Physically fit students (N=35) from the Faculty of Sport Science who had no contra-indication associated with WBV, per the manufacturer's recommendations (epilepsy, diabetes, gallstones, kidney stones, acute inflammation, joint problems, cardiovascular diseases, joint inflammation, thrombosis, or back problems such as hernias and tumours), were included in the study. Three of the subjects were excluded because they could not reach 50 repetitions in an isokinetic fatigue protocol. There were 32 subjects who completed the study. The subjects were subjected to an isokinetic fatigue protocol and were divided into 2 groups according to their fatigue index (FI) results (49.99% or less [MFR, n=17]; 50% or more [LFR, n=15]) (Table 1).

TABLE 1. **DESCRIPTIVE DATA FOR MFR AND LFR GROUPS**

Group	N	Age (years)	Height (cm)	Weight (kg)	BMI (kg/m^2)
MFR	17	20.13±1.92	178±4.97	72.44±6.76	22.92±1.57
LFR	15	22.64±2.02	179±2.02	77.85±8.64	24.03±1.44

MFR= More Fatigue-Resistant LFR= Less Fatigue-Resistant BMI= Body Mass Index

Experimental design

This investigation used a repeated measures design to determine the effects of dynamic WBV on the EMG responses of different fatigue-resistant leg muscles. The neuromuscular activation [EMG Root Mean Square (RMS)] levels of the knee flexor and extensor muscles served as the dependent variables. The independent variables were vibration frequency

(30Hz, 35Hz and 40Hz), vibration amplitude (2mm and 4mm) and vibration group (MFR and LFR). The study comprised 2 interventions: (1) a fatigue protocol session; and (2) the acquisition of Maximum Voluntary Isometric Contractions (MVICs) and a dynamic WBV session. The order of the test conditions was randomised to control for confounding effects, such as familiarisation or fatigue. Each subject visited the Performance and Biomechanics Laboratory at Anadolu University on 2 separate occasions, with at least 2 days separating successive testing sessions.

Data collection

Isokinetic data acquisition and analyses

In the present investigation, a Cybex isokinetic dynamometer (Humac Norm Testing & Rehabilitation System, Stoughton, MA, USA) was used in the fatigue protocol of knee flexor and knee extensor for the dominant legs of the participating subjects. The experimental session started with a standardised warm-up consisting of 5 minutes of cycling on an ergometer without resistance. Each subject was asked to sit on the chair of the dynamometer with a 90° hip angle and was secured to the chair by a belt to prevent movement of the body. The femoral region of the leg at which the measurements were taken was also fastened to the chair with tape. The region of the knee joint coinciding with the rotational axis was adjusted to the same alignment with the input shaft and the starting point was determined while the knee was anatomically at 0°. The range of motion of the knee joint was set at 90°.

The lower leg was fastened to the lever of the dynamometer. The test position was set as recommended by the manufacturer. Before the test, each subject was advised to achieve the full range of motion during each contraction and to push the isokinetic equipment up to its fullest extension and then to re-pull. An isokinetic familiarisation session was conducted at least 48 hours prior to testing. Before the isokinetic tests, the subjects were asked to perform 3 submaximal concentric contractions at a concentric/concentric angular speed of 180° s^{-1} followed by 2 minutes of rest as a warm-up. During the tests, the subjects were asked to perform 50 reciprocal maximal concentric contractions using the dominant knee at an angular speed of 180° s^{-1}. This angular speed was chosen because it is associated with functional activities that require endurance (Seo *et al.*, 2015). Verbal encouragement and visual feedback of the torque value presented on the monitor were used to motivate for maximum effort.

Isokinetic muscle fatigue was defined as the total muscle work developed in all contractions for each muscle group (knee flexors and extensors). To analyse the isokinetic data, knee flexor and extensor muscle fatigue was determined using 2 calculation methods, namely the FI and the slope. The following formula was used to determine the FI (Thorstensson & Karlsson, 1976):

Percentage decrease = 100-[(work last 3 repetitions/work first 3 repetitions) x100]

The initial peak torque was defined as the mean of the first three peak torque values and the final peak torque as the mean of the last 3 peak torque values. The mean peak torque is the mean value across all 50 repetitions. The calculations and index used by Pincivero *et al.* (1997) was described previously. The slope was determined by means of linear regression by

plotting the windowed work values for each repetition across the 50 contractions for each subject. The slope from the calculated regression equation (beta values) for each subject was then calculated to quantify the rate of decrease in quadriceps and hamstring work during the exercise session.

EMG data acquisition and analyses

Surface EMG signals were recorded from the *rectus femoris* (RF), VL, VM and BF muscles

of the dominant leg. BF EMG activity was used to represent hamstring muscle function. The recordings were made using a 16-channel wireless EMG system (Delsys Trigno EMG system, Boston, MA, USA). The gain, frequency band, maximum intra-electrode impedance and common noise removal ratio of the EMG amplifier were 1000, 20 to 500Hz, 6kOhm and 95dB, respectively. The EMG signal sampling and bit rates of the analogue-digital converter were 2000Hz and 16bits, respectively.

The measurement sites were prepared by shaving and lightly abrading the area and subsequently cleaning the skin with alcohol. The surface electrodes were placed longitudinally in relation to the underlying muscle fibre arrangement. In accordance with the Surface Electromyography for the Non-Invasive Assessment of Muscles (SENIAM) recommendations, the centre-to-centre distance between the 2 electrodes was 1cm. In the case of the RF, the sensor was placed at 50% on the line from the *anterior spina iliaca superior* to the superior part of the patella. For the VL, the sensor was placed ⅔ of the way on a line from *the anterior spina iliaca superior* to the lateral side of the patella. For the VM, the sensor was placed 80% of the way on a line between the *anterior spina iliaca superior* and the joint space in front of the anterior border of the medial ligament. In the case of the BF, the sensor was placed midway on a line between the ischial tuberosity and the lateral epicondyle of the tibia (SENIAM).

After the sensor placement session, the MVICs of the muscles were recorded. The MVICs for each muscle were assessed for use as benchmark data. All EMG signals were normalised to the maximum EMG signals recorded during MVICs and presented as the percentage MVIC. MVIC tests were performed with the subject attached to a Cybex isokinetic dynamometer. The MVIC tests of the RF, VL and VM were based on knee extension in a seated position, with the knee at 65° (0° full extension), whereas the MVIC tests of the hamstrings (long head of the BF) were assessed in a prone position with the knee at 30° (Kellis & Baltzopoulos, 1998). The subjects performed 1 trial to understand the task and then performed 2 repetitions, each 5 seconds in duration. During the test, the subjects received standardised verbal motivation to produce maximum effort. A 2-minute rest was allowed between contractions.

Prior to the experimental protocol, a familiarisation session was performed with all subjects to familiarise them with the sensations associated with WBV. The vibration measurements were made using a Compex WINPLATE Galileo 2000 (Novotec Medical GmBH, Germany). The subjects were asked to stand on a WBV platform and were then directed to assume a dynamic squat position with a knee flexion angle between 90° and 150° and with their arms flexed at approximately 90°. Joint angle measurements were collected with a goniometer to ensure that the subjects maintained the required position. A dynamic squat was performed starting from an upright posture with approximately 150° knee flexion. The subjects squatted slowly until approximately 90° knee flexion was achieved. To control the angular velocity of

the flexion and extension movements, a test operator used a metronome at 60bpm concurrently with verbal commands such that the flexion and extension phases of movement each lasted 2 seconds, with a 1-second pause between phases. The subjects were provided verbal feedback about the joint position throughout the protocol and the movement position was self-corrected. The foot position on the platform was marked during the initial trial of each experimental session and the subjects were asked to maintain

their foot position during all trials. The subjects were instructed to direct their head and eyes forward and to distribute their weight equally on both feet.

At the beginning of each measurement, baseline EMG activity (non-vibration) was measured while the subjects were performing a dynamic squat. This procedure allowed an assessment of the contribution of vibration to EMG activity. Baseline EMG measurements were then obtained for 30 seconds and subjects were randomly exposed to 6 different test conditions (frequency [3] x amplitude [2]) on a vibration platform. Each test condition lasted for 30 seconds, with 5 minutes rest between each condition and 10 minutes rest before the 4mm amplitude condition to prevent fatigue.

With the aid of the MATLAB (MathWorks, R2012a), the EMG data was processed. The EMG signals were band-pass filtered (20-450Hz) and smoothed using the RMS values and a 500ms moving-window function (Harput *et al.*, 2013; Harput *et al.*, 2014). Motion artefact components of recorded EMG signals were filtered out using an infinite impulse-response notch filter (3dB band=1.5Hz) centred on the applied vibration stimulus frequency and its harmonics (Fratini *et al.*, 2009). Notch filters were applied for all recordings except the EMG of the resting periods.

Data analysis

The Standard Error of Measurement (SEM) and the corresponding 95% confidence intervals were calculated and subsequently expressed in the units of each variable. Independent-sample t-tests were performed between the calculated FIs for the 2 groups for each isokinetic variable and movement. Values are presented as the mean±standard error (SE). Before statistical analyses, all of the EMG measures were found to be distributed normally based on the Shapiro-Wilk test. The dependent variables in all of the statistical tests were EMG values measured from the RF, VM, VL and BF muscles. The independent variables included the randomisation group (MFR and LFR), vibration frequency (30Hz, 35Hz and 40Hz) and vibration amplitude (2mm and 4mm). Repeated measures analysis of variance (ANOVA) (group [2] x frequency [3] x amplitude [2]) was applied to detect interaction effects between the independent variables. A Bonferroni post hoc test was applied to all pair wise comparisons when a significant result was found. The vibration data were analysed using PASW/SPSS Statistics 18.0 (SPSS Inc., Chicago, IL) and the significance level was set at $p<0.05$.

RESULTS

Descriptive data regarding the single highest repetition values (mean and SD) for absolute peak torque (Nm), absolute mean torque (Nm) and relative mean torque values ($Nm.kg^{-1}$) of

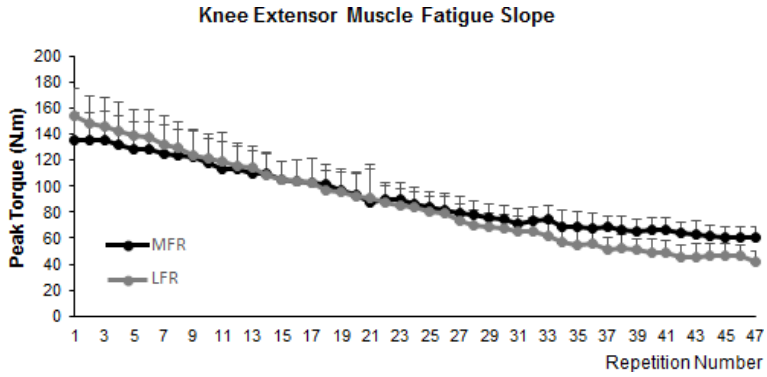
the leg extensor and flexor muscles for both the MFR and the LFR groups are presented in Table 2.

TABLE 2. **SINGLE HIGHEST REPETITION VALUES (MEAN±SD) FOR ABSOLUTE PEAK TORQUE (Nm), ABSOLUTE MEAN TORQUE (Nm) AND RELATIVE MEAN TORQUE VALUES ($Nm.kg^{-1}$)**

Variables	Group	N	Leg Extensor Mean±SD	p-Value	Leg Flexor Mean±SD	p-Value
Absolute peak torque (Nm)	MFR	17	139.16±4.62	0.019*	95.30±5.01	0.014*
	LFR	15	158.46±7.48		106.10±5.45	
Absolute mean torque (Nm)	MFR	17	86.53±8.41	0.001**	64.06±6.70	0.001**
	LFR	15	145.73±7.50		96.06±5.73	
Relative mean torque ($Nm.kg^{-1}$)	MFR	17	119.60±12.03	0.001**	87.00±10.94	0.007*
	LFR	15	192.40±6.49		128.00±7.28	

*p<0.05 **p<0.001

As shown in Table 2, the LFR group had significantly higher absolute peak torque, absolute mean torque and relative mean torque values of the leg extensor muscles when compared with the MFR group. The LFR group also had significantly higher absolute peak torque, absolute mean torque and relative mean torque values of the leg flexor muscles when compared with the MFR group.



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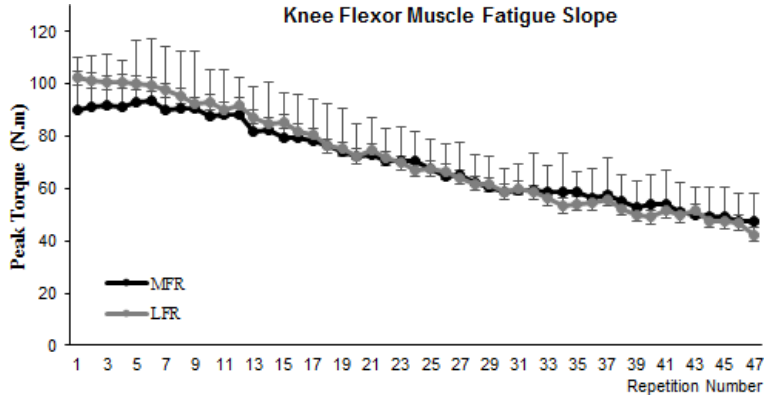

FIGURE 1. **LINEAR SLOPE FOR MEAN KNEE EXTENSOR AND FLEXOR PEAK**

TORQUE DURING 50 MAXIMAL-EFFORT CONCENTRIC REPETITIONS

Figure 1 shows the decrease in work output, measured as the linear slope for the knee extensor and flexor muscles of the MFR and LFR groups. The findings of the present study demonstrate that the LFR group experienced a significantly higher rate of muscle fatigue of the knee extensor and knee flexor when compared with the MFR group ($p \leq 0.001$). Table 3 and Table 4 indicate the knee extensor and flexor FI and slope rates, respectively.

TABLE 3. **DESCRIPTIVE DATA OF KNEE EXTENSOR AND FLEXOR FATIGUE INDEX (FI%) FOR MFR AND LFR GROUPS**

Group	n	Knee extensor Mean±SD	95% CI	p-Value	Knee flexor Mean±SD	95% CI	p-Value
MFR	17	46.08±2.29	42.52-49.64	p≤0.001	32.43±3.51	25.21-38.73	p≤0.001
LFR	15	69.54±1.33	67.15-72.14	p≤0.001	56.59±3.41	44.28-57.77	p≤0.001

TABLE 4. **DESCRIPTIVE INFORMATION REGARDING KNEE EXTENSOR AND FLEXOR SLOPE (Nm.rep^{-1}) FOR MFR AND LFR GROUPS**

Group	n	Knee Extensor Mean±SD	95% CI	R^2	p-Value	Knee Flexor Mean±SD	95% CI	R^2	p-Value
MFR	17	-0.54±1.53	-0.51-(-0.57)	0.96	p≤0.001	-0.87±1.40	-0.83-(-0.91)	0.98	p≤0.001
LFR	15	-0.40±0.9	-0.38-(-0.42)	0.97	p≤0.001	-0.73±1.37	-0.69-(-0.76)	0.97	p≤0.001

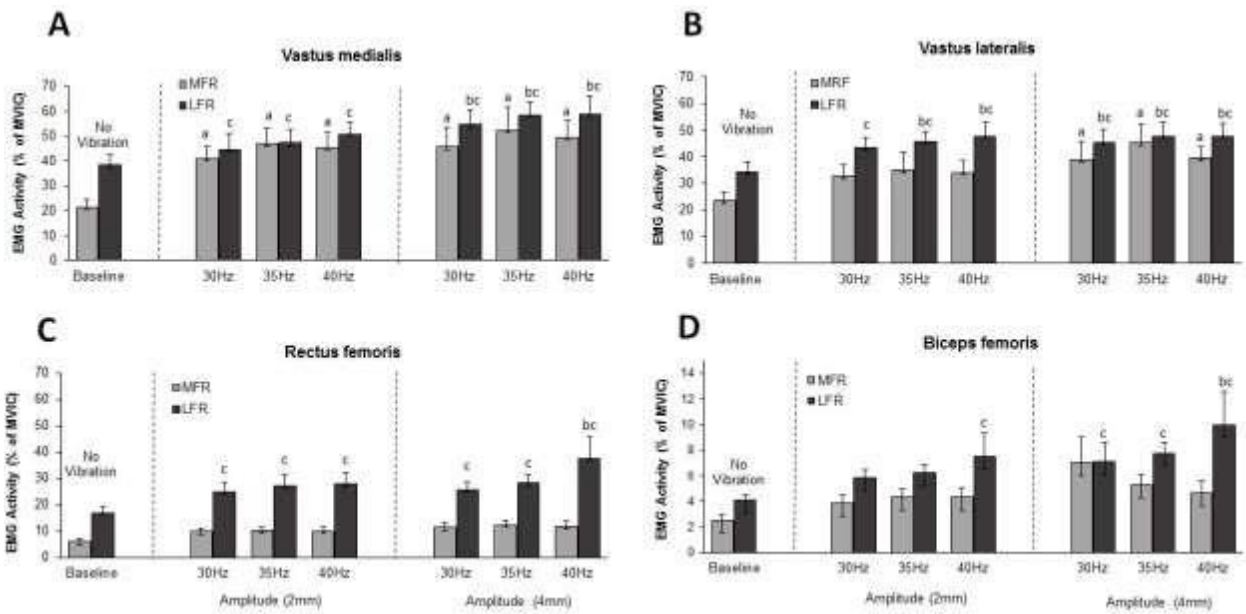

FIGURE 2 (A-D). **INCREASES IN MUSCLE ACTIVITY WITH WBV COMPARED WITH NON- WBV DURING A DYNAMIC SQUAT**

Black and open bars show the EMG activity of the LFR and MFR groups, respectively, at different frequencies and amplitudes. Values are the mean±SE. Significantly greater than baseline: $p<0.05$.
Different letters (a, b, c) indicate significant differences in activity levels between frequencies during either high- or low-amplitude vibration.

MFR Group Baseline-MFR Group: 30, 35, 40Hz (2mm) / 30, 35, 40Hz (4mm) **a** ($p<0.05$). LFR Group Baseline-LFR Group: 30, 35, 40Hz (2mm) / 30, 35, 40Hz (4mm) **b** ($p<0.05$). MFR Group Baseline-LFR Group: 30, 35, 40Hz (2mm) / 30, 35, 40Hz (4mm) **c** ($p<0.05$).

1
5
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Figure 2 shows the increases in VM, VL, RF and BF muscle activity with WBV compared with non-WBV and the differences between the LFR and MFR groups with respect to EMG activities for all frequencies and amplitudes during a dynamic squat.

VM muscle

Figure 2-A represents the VM muscle activity. The VM EMG RMS activity was consistently higher in the WBV condition when compared with the non-vibration condition. Statistical analyses confirmed significant main effects of 'group' ($F_{(1,330)}=77.41$; $p<0.001$), 'frequency' ($F_{(3,330)}=27.52$; $p<0.001$) and 'amplitude' ($F_{(2,330)}=65$; $p<0.001$) on the EMG response. In addition, significant interaction effects were found for 'group x amplitude' ($F_{(2,330)}=5.54$; $p<0.001$) and 'frequency x amplitude' ($F_{(6,330)}=7.59$; $p<0.001$). However, 'group x frequency' and 'group x amplitude x frequency' interactions were not significant ($p>0.05$).

VL muscle

As shown in Figure 2-B, the EMG RMS activity of the VL muscle was consistently higher in the WBV condition than in the non-vibration condition. Statistical analyses confirmed significant effects of 'group' ($F_{(1,330)}=118.07$; $p<0.001$), 'frequency' ($F_{(3,330)}=24.87$; $p<0.001$) and 'amplitude' ($F_{(2,330)}=59.28$; $p<0.001$) on the EMG response. In addition, a significant interaction effect was determined for 'frequency x amplitude' ($F_{(6,330)}=6.95$; $p<0.001$), but not for 'group x frequency', 'group x amplitude' nor 'group x amplitude x frequency' interactions ($p>0.05$).

RF muscle

Figure 2-C represents the activity of the RF muscle. The RF EMG RMS activity was consistently higher in the WBV condition than in the non-vibration condition. Statistical analyses confirmed significant effects of 'group' ($F_{(1,330)}=311.66$; $p<0.001$), 'frequency'

($F_{(3,330)}$=5.06; p<0.001) and 'amplitude' ($F_{(2,330)}$=10.48; p<0.001) on the EMG response. There were no significant effects for 'group x amplitude', 'group x frequency', 'frequency x amplitude' and 'group x amplitude x frequency' interactions (p>0.05).

BF muscle

Figure 2-D represents the activity of the BF muscle. BF EMG RMS activity was consistently higher, although the difference was not always significant in the WBV condition when compared with the non-vibration condition. Statistical analyses confirmed significant effects for 'group' ($F_{(1,330)}$=31.55; p<0.001), 'frequency' ($F_{(3,330)}$=7.38; p<0.001) and 'amplitude' ($F_{(2,330)}$=19.54; p<0.001) on the EMG response. In addition, an interaction effect of 'frequency x amplitude' ($F_{(6,330)}$=6.95; p<0.001) on the EMG response was found, but not for 'group x amplitude', 'group x frequency' and 'group x amplitude x frequency' interactions (p> 0.05).

The results showed that the all recorded leg muscles were affected differently by the different amplitudes, frequencies and groups:

- Significant *group* main effects were found, revealing that the EMG activity of the LFR group was significantly higher than that of MFR leg muscle group (p<0.05).

- Significant *amplitude* main effects were found revealing that the 4mm amplitude resulted in significantly greater EMG activity than the 2mm amplitude did in all tested muscles (p<0.001).
- Significant *frequency* main effects were found, revealing that compared with non-WBV, WBV resulted in significantly greater EMG activity in all tested muscles (p<0.001).
- Significant *interaction* effects were observed between the amplitude and vibration frequency (amplitude x frequency) with respect to the EMG activities of the VM, VL and BF (p<0.001). In the LFR group, the highest frequency (40Hz) and amplitude (4mm) resulted in significant increases in EMG activities in the VM, VL, RF (p≤0.001) and BF (p<0.05). The highest level of muscular activation in the MFR group was observed at the frequency of 35Hz and amplitude of 4mm and thereafter tended to decrease in the VM, VL, RF and BF. However, these decreases were only significant for the VM and VL (p<0.001).

DISCUSSION

Most of the studies previously conducted on this topic have focused on the acute and chronic effects of WBV on neuromuscular performance. Although interest in WBV is steadily increasing, little is known about the neuromuscular mechanism through which WBV acts, about how the human body responds to WBV or about the type of WBV stimulus (frequency x amplitude) that would be optimal for the development of the most beneficial individual treatment protocols. In some studies, muscle strength increased (Bosco & Komi, 1979; Torvinen *et al*., 2002; Roelants *et al*., 2004; Delecluse *et al*., 2005), whereas in other studies muscle strength did not change (Delecluse *et al*., 2003; De Ruiter *et al*., 2003; Cochrane & Stannard, 2005). According to the findings of these studies, individual differences are found across subjects. Thus, the response to the applied combination of frequency and amplitude could be different, causing controversial issues related to applications. In this study, to decrease the individual differences in the subjects, all subjects were grouped according to the level of fatigue resistance of leg muscle. Aside from these studies, no other studies

investigating the effects of dynamic WBV on the EMG responses of different fatigue-resistant leg muscles could be found in the literature. Considering the information above, the aim of the present study was to investigate the effects of WBV stimuli at low (2mm) and high (4mm) amplitudes and at various frequencies (30Hz, 35Hz and 40Hz) on the EMG responses of different fatigue-resistant leg muscles during dynamic leg squats.

The first hypothesis of this study was confirmed. The muscle activities of the LFR and MFR groups significantly increased at all WBV frequencies compared with those at the non-vibration baseline measurement. Most studies investigating WBV exercise protocols implemented frequencies between 15Hz and 60Hz (Cardinale & Wakeling, 2005). Surface EMG analyses in different studies have demonstrated significantly increased muscular activity and several studies have reported that the EMG increase is frequency-dependent (Matthews, 1966; Issurin & Tenenbaum, 1999; Bosco *et al*., 2000; Cardinale & Lim, 2003; Luo *et al*., 2005; Roelants *et al*., 2006; Hazell *et al*., 2007; Fratini *et al*., 2009; Pollock *et al*., 2010; Di Giminiani *et al.*, 2013). Matthews (1966) suggested that the level of muscle response to mechanical vibration depends on the applied frequency and that higher frequencies would lead to greater muscle activity.

The findings of the study by Cardinale and Jin (2003) revealed higher EMG activity with WBV when compared to the non-vibrating condition, supporting the results of the present study. Hazell *et al*. (2007) investigated the effects of WBV during dynamic and static contractions of the upper and lower body. These authors showed that WBV stimuli at different frequencies and low or high amplitudes caused significant increased EMG RMS muscle activity. In particular, frequencies from 35 to 45Hz and frequencies with higher amplitude (4mm) resulted in greater muscular activation. In another study, Pollock *et al*. (2010) examined the effects of frequency and amplitude on the activity and acceleration value of six leg muscles during WBV. They observed that the muscular activation values were greater, although not always significant, at high amplitudes and at all frequencies.

Perchthaler *et al*. (2013) reported changes in the neuromuscular activity of thigh muscles during WBV by incorporating various biomechanical variables. These findings showed that different frequency and amplitude combinations resulted in different ratios of EMG percentage MVICs. Muscular activation increased linearly with increasing frequency, except in the *gluteus maximus* and BF muscles (Perchthaler *et al*., 2013). Krol *et al*. (2011) suggested that the level of muscle response to mechanical vibration depended on the applied frequency and that higher frequencies would lead to greater muscle activity. These improvements in muscle performance following acute WBV exposure are considered to be associated with numerous different mechanisms.

The most often cited mechanism proposed to explain these effects of WBV exposure is the 'tonic vibration reflex' (TVR). The higher frequency and amplitude of the EMG signal obtained from the abdomen of the examined muscles indicate a larger number of simultaneously stimulated motor units, as well as a better synchronisation of their stimulation (Hazell *et al*., 2007; Cardinale & Erskine, 2008). The TVR produces involuntary rapid changes in muscle length and increases muscle activation (Hagbarth & Eklund, 1966) via vibration perturbation. Furthermore, the recruitment thresholds of motor units decrease (Romaiguere *et al*., 1993) and activating a larger portion of the motor unit pool (Issurin & Tenenbaum, 1999), augments EMG. These mechanisms indicate that exposure to WBV can stimulate the neuromuscular system. In fact, the results of these studies show that WBV

elicits higher EMG activity than the non-vibrating condition. However, different vibration frequencies elicit different EMG responses in the stimulated muscles.

The second hypothesis of this study was confirmed because in the comparison of different fatigue-resistant leg muscles, the LFR group demonstrated higher muscle EMG activation than the MFR group at all frequencies. Under exposure to WBV, the highest EMG activity in the LRF group was recorded when the frequency was 40Hz. Thus, the highest frequency elicited the greatest reflex response in the LFR muscle during dynamic WBV. Therefore, a stimulus with a higher frequency may potentially lead to improvements in the performance of LFR group leg muscles. However, the highest level of muscular activation in the MFR groups was observed at a frequency of 35Hz. The muscle activation of the MFR group decreased as the WBV frequency increased. This finding may be associated with the different characteristics of absolute torque production of the LFR and MFR groups. During 50 maximal-effort concentric repetitions, the LFR group displayed significantly higher absolute peak torque (Nm), absolute mean torque (Nm) and relative mean torque values ($Nm.kg^{-1}$) for the extensor and flexor leg muscles than did the MFR group. This finding can be explained

by the individual differences in the number of myofibrils in each muscle fibre, muscle fibre recruitment and frequency; the number of sarcomeres in series; and the arrangement of muscle fibres relative to the axis of force generation, that is the muscle architecture (Enoka, 2008).

Vibration amplitudes are important variables that affect muscle activity during vibration stimuli (Martin & Park, 1997). The literature reports amplitudes ranging from 2mm to 10mm (Cardinale & Wakeling, 2005). However, the selective effects of different vibration-amplitude parameters are not clearly understood. A wide variety of frequencies, amplitudes and durations of exposure has been used in different study protocols. Krol *et al*. (2011) suggested that EMG activity significantly increased with both amplitude and frequency, with EMG activity reaching its highest level when the frequency and amplitude reached 60Hz and 4mm, respectively. The same vibration frequency at different amplitudes (2mm and 4mm) resulted in significantly higher EMG activity at 4mm. The findings of the present study showed that a significant 'amplitude' effect was found on the EMG response of LFR and MFR leg muscles. In comparing different amplitudes, the higher amplitude (4mm) demonstrated greater muscle activation of LFR and MFR leg muscles.

From a practical point of view, lower frequencies and higher amplitudes (35Hz and 4mm, respectively) of vibration may enable individuals with MFR muscles to achieve maximal muscular activation. However, the EMG data from this study demonstrate that higher WBV frequencies and amplitudes (40Hz and 4mm) elicit the greatest increases in muscle activity with LFR muscles and emphasise that selection of the correct frequency and amplitude is likely critical for optimal performance improvement.

CONCLUSION

In conclusion, the objective of this study was to evaluate the effects of dynamic WBV stimuli on the EMG responses of different fatigue-resistant leg muscles. The results show that dynamic WBV has a positive effect on muscle EMG activities, which are dependent on the vibration frequency and amplitude and the group (MFR and LFR). Based on these results, the present study can be used as a reference to pave the way for the development of an effective

individual WBV exercise program, including primary assessment of the individual's or athlete's muscle fatigue index and determining the training intensity to reach the optimal vibration stimulus for the LFR or MFR leg muscles.

Finally, identifying an optimal stimulus resulting in the greatest increase in muscle activity should aid in the development of optimal vibration exercise prescriptions and can serve as a guide for the development of training or rehabilitation programmes. The optimal frequency, optimal amplitude and muscle activation level that would benefit most from vibration stimulation must all be identified to induce specific adaptations. Moreover, different fatigue-resistant leg muscle groups react differently to the applied frequency. This implies grouping the vibration frequency according to the ratio of fatigue resistance that can elicit the greatest reflex response during WBV. WBV performed according to the ratio of fatigue resistance may boost performance in a shorter time compared with WBV performed using a fixed frequency.

RECOMMENDATIONS

This study has some methodological limitations. Three vibration frequencies of 30Hz, 35Hz and 40Hz and two amplitudes of 2mm and 4mm were applied. Muscular activation values of the LFR group were highest at a frequency of 40Hz. Further studies should be conducted to determine the muscular activation pattern at higher frequencies (45Hz and higher) for individuals with LFR leg muscles and at higher amplitudes for individuals with LFR and MFR leg muscles. Another limitation was the squat position. This application has been performed only in a dynamic squat position. Future studies that use different knee flexion angles and a static squat position are needed. In this study, the LFR and MFR groups were determined according to isokinetic torque responses. Further studies should determine the ratio of distribution of fatigue-resistant fast-twitch (type II) and fatigue-sensitive slow-twitch (type I) fibres with biopsy or phosphorus magnetic resonance spectroscopy methods. The LFR and MFR groups can be determined according to the composition of muscle fibre type because of individual responses and the effectiveness of individualised treatments on neuromuscular performance.

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NON-VOLUNTEERISM OF UNIVERSITY SPORT STUDENTS: A LEISURE CONSTRAINTS THEORY APPROACH

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ABSTRACT

Research indicates that student volunteerism has declined in numerous countries. The current South African sport industry is heavily dependent on volunteers to deliver services in communities and at sporting events. A serious effort may be necessary to successfully and positively recruit and manage volunteers. The purpose of this study was to identify factors, which may constrain volunteerism amongst university sport students. Data were collected from an in-class convenience sample utilising a self-administered questionnaire to students (N=279) enrolled in a sport curriculum at two universities in the Gauteng Province. The volunteer questionnaire of Auld and Cuskelly was used to gather data. Of the returned questionnaires, 153 students classified themselves into the category of "never volunteered before" and completed that specific section of the questionnaire. These responses were included in the study. An Exploratory factor analysis using Principal Components Analysis was conducted to identify constraining volunteer factors for sport students. Five factors emerged, namely 'organisation environment perception', 'perceived workload', 'psychological aspects', 'perceived lack of skills' and 'time constraints'. This study provides a promising contribution in identifying factors constraining volunteering amongst university sport students.

Key words: Volunteerism; University sport students; Leisure constraints.

INTRODUCTION

Volunteers have played an important role in the enduring operations of numerous public and private agencies throughout the years (Liao-Troth & Diunn, 1999). The success of many profit and non-profit organisations would have been diminished had it not been for voluntary and personal hours dedicated to a cause without fiscal compensation (Gage & Thapa, 2012). According to results from the first Volunteers Activity Survey (VAS) conducted by Statistics

South Africa in 2010, 1.2 million people over the age of 15 years participated in volunteer activities for that year (Statistics South Africa, 2010). These volunteers contributed a total of 379 million hours at an average of 6.1 hours per week of volunteer activities with an estimated value of R7.5 billion had they been remunerated. In particular, women contributed 256 million hours at an average of 6.4 hours per week, amounting to R4.4 billion. In the same time frame, men contributed 123 million hours at an average of 5.6 hours per week, estimated at a value of R3.1 billion (Statistics South Africa, 2010). The overall financial benefit of 'free

labour' to organisations through volunteerism is immense and, at the same time they increasingly depend on services provided by volunteers (Cravens, 2006).

Volunteering by university students

Volunteer recruitment programs often target university students due to their apparent enthusiasm for involvement in major sporting events, their tendency to engage positively in community work related in-service learning and their attitude of volunteer involvement with benefits of a future job in sight (Auld, 2004; Handy *et al*., 2010; Gage & Thapa, 2012). Behavioural characteristics of students regarding volunteerism have been well investigated (Auld, 2004), with several studies indicating that student volunteer activities have declined (Gaskin, 2004; Cruce & Moore, 2007). The national statistics of volunteer rate by age indicate that the age category of 15 to 24 years have a volunteer rate of 1.2% (Statistics South Africa, 2010). This is the lowest of all the age categories in the country, which suggests that the student-aged population are the least involved in volunteer activities (Statistics South Africa, 2010).

The South African sport industry is heavily dependent on volunteers to deliver services in communities and at sporting events. In this regard, organisations could focus more on the recruitment of sport students to fulfil this need (Goslin *et al*., 2004; Goslin, 2006). Francis (2011) also posit that university students are an under-researched population related to volunteerism with the majority of research focused on student motivations and characteristics to successfully volunteer. However, there is a need for identification and clarification of constraining factors to volunteerism for university students (Cruce & Moore, 2007; Smith *et al*., 2010). The focus of this study was to identify factors constraining university sport students from engaging in volunteer activities.

Leisure constraints framework

The hierarchical leisure constraints model first presented by Crawford and Godbey (1987) and expanded by Jackson *et al*. (1993), has been widely accepted as an important lens through which to view leisure behaviour, including volunteerism (Green & Chalip, 1998). Crawford *et al*. (1991) classified constraints into three categories, namely intrapersonal, interpersonal and structural. Intrapersonal constraints are individual psychological states and attributes that affect preference and lead to non-participation (Crawford & Godbey, 1987). Examples of intrapersonal constraints include lack of interest, stress, attitude, anxiety and perceived lack of skill (Godbey *et al*., 2010; Gage & Thapa, 2012). Interpersonal constraints occur because of the unavailability of other people and which co-participants perceive prevents them from participation (Gage & Thapa, 2012). This could include an aspect, such as "not knowing who one will work with" (Cleave & Doherty, 2005) and unlike intrapersonal constraints, interpersonal constraints relate to both preferences and participation (Crawford & Godbey, 1987). Structural constraints are the intervening factors between leisure preference

and participation (Crawford & Godbey, 1987) and include factors such as lack of time, money, opportunity, information and access (Cleave & Doherty, 2005; Gage & Thapa, 2012).

Volunteerism constraints of university students

Astin and Sax (1998) posit that students often avoid volunteering since it consumes time and energy, which they could have devoted to their academic pursuits or paid work to support their time studying. When students perceive their time spent on volunteering as affecting themselves negatively, they may be less motivated to volunteer. Students have a tendency to strive towards fulfilling their own needs before serving others and in this regard students identified "a lack of time" as the most common constraint preventing them from volunteering (Auld, 2004; Hyde & Knowles, 2013). Lack of time is an understandable constraint with students having separate or coinciding study and work commitments that leaves little time for other obligations such as volunteering (Auld, 2004; Hyde & Knowles, 2013). Various studies have been conducted to identify barriers to volunteering and "a lack of time", "no interest", "health problems", "don't know how to get involved" and "too many other commitments" have been some of the most prominent factors (Cleave & Doherty, 2005).

Several studies investigated barriers and constraining factors of leisure behaviour (Cleave & Doherty, 2005; Gage &Thapa, 2012). Intrapersonal constraints identified by young people included low self-esteem (Raymore *et al*., 1994), gender roles, lack of self-confidence (Culp, 1998), lack of skills (Jackson & Rucks, 1995) and lack of motivation (Caldwell *et al*., 1999). Family, other adults (programme leaders and coaches) and peers influenced interpersonal leisure constraints (Shannon, 2006; Gage &Thapa, 2012), while young people identified structural constraints that included lack of time (Jackson & Rucks, 1995; Gage & Thapa, 2012; Van den Berg & Cuskelly, 2014), perceived lack of opportunity (Hendry *et al*., 2002; Auld, 2004) and lack of accessible opportunities (McMeeking & Purkayastha, 1995). These constraints varied by population (Whyte & Shaw, 1994), age (Scott & Jackson, 1996), ethnicity (Stodolska & Yi-Kook, 2005) and socio-economic status (Scott & Munson, 1994). In this regard, individuals from different social, cultural and historical contexts do not perceive the constraints similarly and of equal importance (Godbey *et al*., 2010).

PURPOSE OF THE RESEARCH

The purpose of this study was to identify constraining factors of university sport students to volunteer, using the Leisure Constraints Model of Godbey *et al*. (2010) as a theoretical framework.

METHODOLOGY

Design

University sport students have a propensity to volunteer in sport events and activities mainly in order to gain valuable work-related experience (Friedland & Morimoto, 2005; Gage & Thapa, 2012). Hence, a purposive sampling method was utilised in the light of appropriateness of a sample of university students to investigate the constraining factors contributing to avoiding volunteering by sport students. Data were collected from an in-class convenience sample utilising a self-administered questionnaire.

Sample

First, second and third year students in three different sport curriculum programmes at two universities within the Gauteng Province completed the questionnaire.

Procedure

One of the researchers scheduled time with lecturers of the sport programmes to administer the questionnaire during regularly scheduled class times. The researcher clarified the definition of a volunteer according to the definition by Statistics SA (2010:online) as "A person who actively and willingly performed for little or no payment, to provide assistance or promote a cause, either through an organisation or directly for someone outside one's own household or immediate family". The researcher briefly explained the existence of different types of volunteer organisations, such as profit or non-profit, government or non-government. After the short introduction and explanation on volunteerism, students were asked to complete the questionnaire.

Ethical administrative procedures

The relevant authorities from both respective universities granted permission for the study. The purpose of the study was explained to all participants and students were informed that participation was voluntary and anonymous and that results would be used for research purposes only. Since the study focussed on a specific student target group, in order to maintain anonymity, institutions requested to remain anonymous.

Instrument

The questionnaire was based on an instrument originally developed by Auld and Cuskelly (1999). The questionnaire contains 5 sections. Section 1 referred to demographic information and in section 2, the respondents categorised themselves into 1 of 3 categories of volunteering:

- never volunteered for a community based organisation (section 3),
- used to volunteer for a community based organisation but stopped (section 4); or
- currently volunteering for a community-based organisation (section 5).

Those students who had categorised themselves as 'never volunteered before' completed only that section (section 3) of the questionnaire. The results of the responses of these students were investigated and reported on in this study. In the category of 'never volunteered before', the students responded to a series of statements pertaining to the nature of their non-participation in volunteering. Responses were measured on a 5-point Likert-type scale with the options, *strongly disagree, disagree, neither disagree nor agree, agree* and *strongly agree*.

Analysis of data

Data were analysed through the Statistical Package for Social Sciences (SPSS – version 21) (StatSoft, 2014). Descriptive statistics were computed to profile the participants regarding gender, age group and ethnic group. Secondly, an exploratory factor analysis was conducted

to identify the factors that constrained university sport students from volunteering. Cronbach's alpha values were computed for each factor to ascertain inter-item reliability. Internal consistency for the factors 1 to 5 scored 0.75, 0.68, 0.68, 0.65 and 0.65 respectively. Nunnally and Bernstein (1994) suggests that values of 0.7 or above may be considered good and 0.6 or above considered adequate for any factor with a small number of items. Hence, it may be implied that the reliability of the factors identified in this study ranged from adequate to good and may be applied in similar settings in future research.

RESULTS

Demographics

Of the 359 enrolled students within a sport curriculum program at two universities, 279 (77.7%) students completed the volunteer questionnaire. Of the 279 completed and returned questionnaires, 153 students classified themselves into the category of 'never volunteered before'. Hence, the data analysis for this study was conducted on the responses of 153 students yielding a figure of 54.8% of the respondent sport students who never volunteered before.

TABLE 1. **DESCRIPTIVE STATISTICS OF PARTICIPANTS**

Demographic information	%	n
Gender		
Male	66.4%	101
Female	33.6%	52
Age group		
18-19 years	23.7%	36
20-21 years	45.4%	69
22-23 years	23.0%	35
24 years and older	7.9%	12
Ethnic group		
Black	82.9%	126
White	15.1%	23
Coloured	1.3%	2
Other	0.7%	1

Of the 153 participants, 66.6% were male and 33.6% were female. The majority of the participants (45.4%) were in the 20 to 21 years old age category, followed by the 18 to 19 years category (23.7%) and the 22 to 23 years category (23%). Only 7.9% of the participants were 24 years or older. More than three-quarters of the participants (82.9%) were categorised as black/African, 15.1% as white, 1.3% as coloured and 0.7% as other, such as Indian/Asian.

Exploratory factor analysis

All 29 volunteer constraint items were entered into the first PCA and resulted in 10 factors accounting for 64.3% of the overall variance being identified (KMO=0.776; Bartlett's Test of

Sphericity=1140.030; df=210; p=0.000). An examination of the items revealed that 8 items did not load cleanly (within 0.3 of each other), which were discarded for the subsequent factor

analysis. A second PCA was conducted on the remaining 21 items (KMO=0.788; Bartlett's Test of Sphericity=796.152; df=210; p=0.000), which resulted in 6 factors that accounted for 58.3% of the total variance extracted. Three items did not load cleanly on a factor and subsequently they were removed to reduce ambiguity in the interpretation of the factors (Tabachnick & Fidel, 2001). The third PCA (KMO=0.804; Bartlett's Test of Sphericity=700.358; df=153; p=0.000), extracted 5 factors which accounted for 58.4% of the total scale variance. The final factor structure is provided in Table 2.

TABLE 2. **ROTATED COMPONENT MATRIX**

Factor and variable description	**1**	**2**	**3**	**4**	**5**
Factor 1: Organisation environment perception (α=0.75)					
I don't think my work would be recognised or rewarded	0.753	-0.011	0.036	0.190	0.201
I don't like the ways most voluntary community organisations are run	0.559	0.385	0.239	0.226	-0.056
I would not enjoy working with paid staff	0.685	0.236	0.122	0.104	-0.145
I might be taken advantage of by the organisation	0.514	0.491	0.059	0.078	0.201
I don't want to be bossed around	0.517	0.222	0.223	-0.039	0.204
Factor 2: Perceived work load (α=0.68)					
I might feel obligated to put in an unreasonable number of hours	0.281	0.743	-0.040	-0.007	-0.034
Volunteers have poorer working conditions than paid staff	0.321	0.749	0.017	0.063	0.108
Volunteers work too hard	-0.143	0.667	0.357	0.241	0.231
Factor 3: Psychological aspects (α=0.68)					
I wouldn't have fun	0.116	0.286	0.693	0.105	0.173
I have an illness or disability that prevents me	0.050	-0.034	0.750	0.033	-0.088
I don't think volunteering is very important	0.313	-0.076	0.674	0.071	0.072
Volunteers get too stressed	0.004	0.224	0.519	0.319	0.360
Factor 4: Perceived lack of skills (α=0.65)					
I don't have the skills required	0.382	0.123	0.007	0.631	-0.031
I am not organised enough	0.058	0.127	0.117	0.786	-0.032
I don't have enough confidence	0.056	-0.026	0.116	0.764	0.008
Factor 5: Time constraints (α=0.65)					
I have too many responsibilities	-0.014	0.048	0.049	-0.027	0.690
I have too many other commitments	0.032	0.162	-0.002	-0.133	0.736
I don't have enough time	0.196	-0.027	0.115	0.119	0.693
Eigenvalues	4.70	1.81	1.67	1.20	1.13
% of Variance	26.13	10.04	9.30	6.65	6.28
Cumulative variance	26.13	36.17	45.46	52.11	58.38

DISCUSSION

This study was conducted to identify constraining factors for university sport students to volunteer in community-based organisations. Five factors, labelled *organisation environment perception, perceived workload, psychological aspects, perceived lack of skills* and *time constraints* were identified through an exploratory factor analysis. The study identified two

structural and three intrapersonal constraints with very little evidence of interpersonal constraining factors. This could be a function of the measurement instrument not specifically designed with the Leisure Constraints Model in mind or that interpersonal constraints are of less importance for this specific student population.

Organisation environment perception

The first factor, *organisation environment perception*, accounted for 26.1% of the variance and had an Eigenvalue of 4.70. This factor possibly is indicative of preconceived perceptions of the university sport students that volunteer organisations are not favourable places to spend energy and effort. This belief is illustrated through their response that 'their work would not be recognised or rewarded'. Students indicated further negative perceptions regarding 'working with paid staff' at volunteer organisations or feared 'being bossed around or taken advantage of'. This negative organisation perception illustrated by the first factor is similar to the findings by Hyde and Knowles (2013) that identified a lack of awareness and/or knowledge about volunteering as a primary factor constraining students from volunteering. Their study indicated the deficit in knowledge of students to identify and engage in suitable organisations, as well as a lack of understanding the volunteer process and activities (Hyde & Knowles, 2013).

The deliberate choice of the students not to volunteer may possibly be assigned to the inefficiency of organisations to communicate the possible favourable benefits of volunteering to students (Bringle & Hatcher, 1996). This suggests that measures could be taken to ensure that students are less likely to perceive volunteer activities and organisations as controlling (Gage & Thapa, 2012). This factor could also be classified as a structural constraint since these refer to factors, such as a lack of opportunity of volunteering in a positive environment and lack of information on participation and accurate experiences (Cleave & Doherty, 2005; Gage & Thapa, 2012).

Perceived workload

The second factor accounted for 10.0% of the variance with an Eigenvalue of 1.80. Within this factor, students identified 'they might feel obligated to put in an unreasonable number of hours' and they perceived 'volunteers work too hard'. This factor is similar to constraining factor of emotional cost of volunteering reported by Hyde and Knowles (2013), where students indicated that they felt emotionally drained from community work and would rather focus on their own well-being. Volunteer organisations could endeavour to improve the perception that volunteering 'costs' too much in developing positive attitudes in considering how volunteering could benefit their current situation (Auld, 2004; Hyde & Knowles, 2013). Benefits of personal relevance, such as spending time with friends or family while volunteering, or volunteering at a work-related organisation for future job opportunities (Auld, 2004; Hyde & Knowles, 2013), should be encouraged to overcome this constraining

factor. This factor can be classified as a structural constraining factor in the context of the Leisure Constraints Model (Crawford & Godbey, 1987).

Psychological aspects

The third factor, *psychological aspects*, accounted for 9.3% of the variance with an Eigenvalue of 1.67. This factor is classified as an intrapersonal constraining factor since it

depicts the attitude and psychological state of mind of the specific group that could refer to aspects, such as lack of interest, stress, attitude, anxiety and perceived non-enjoyment (Godbey *et al*., 2010; Gage & Thapa, 2012). Shannon *et al*. (2009) identified the lack of enjoyment as a constraining factor for volunteering by youths, which associates with an item in the current study identified as 'I wouldn't have fun' within this factor. Students enjoy the company of their friends and experiences where they were not able to socialise with them during volunteer events affect their enjoyment of the volunteer activity (Shannon *et al*., 2009).

A lack in knowledge, relating to opportunities for socialising and enjoyment that can be achieved through volunteer activities, can also be linked to this psychological state of mind and could be overcome by organisations through proper communication during the recruitment phase (Auld, 2004). The item of 'volunteers get too stressed' is another cognitive perception, which influences the decision of sport students not to volunteer. This relates to the identified factor of emotional cost of volunteering by Hyde and Knowles (2013). Students experience stress due to their studies and will not eagerly become involved for the benefit of the community or the cause itself, especially if it will be at their own personal and emotional cost (Shannon *et al*., 2009; Handy *et al*., 2010). Similarly, the item 'I don't think volunteering is very important' also correlates with the second constraining factor of lack of motivation and interest for volunteering reported by Hyde and Knowles (2013). Many students portray a lazy or unbothered attitude towards volunteering, which is why, according to Goslin *et al*. (2004), a serious effort, has to be made to address the negative culture of volunteering in the country.

Perceived lack of skills

The fourth factor, *perceived lack of skills*, accounted for 6.7% of the variance with an Eigenvalue of 1.20. The items of 'I don't have the skills required', 'I am not organised enough' and 'I don't have enough confidence', portrays perceived lack in skills of the sport students in order to engage successfully in volunteer activities. This factor relates to the findings of Hyde and Knowles (2013), whereby students indicated a lack of belief in their own capacity to contribute successfully to a volunteer organisation, of which very little further research exists that explains this identified factor (Jackson & Rucks, 1995). The lack of perceived efficacy will directly influence a student's inclination to volunteer (Hyde & Knowles, 2013). Respondents in the current study seem to hold the perception that volunteering requires significant skills and knowledge. In this regard, this factor of *perceived lack of skills* can be classified as an intrapersonal constraining factor.

Time constraints

The fifth factor, namely *time constraints*, accounted for 6.3% of the variance with an Eigenvalue of 1.13. Time constraints have been identified as a major constraining factor for many university students within many different countries (Jackson & Rucks, 1995; Hyde & Knowles, 2013; Van den Berg & Cuskelly, 2014). Students reported separate or simultaneous work and study commitments (Gage & Thapa, 2012; Hyde & Knowles, 2013), together with the current economic environment, which necessitates them to pursue part-time work to supplement their study and living expenses (Manthei & Gilmore, 2005). This could explain the lack of time to volunteer. Students also reported family and other responsibilities they need to fulfil as a time constraint (Gage & Thapa, 2012; Van den Berg & Cuskelly, 2014). This factor is classified as an intrapersonal constraint (Crawford *et al*., 1991), that often is an

indicator of a lack in the priority given to volunteering.

CONCLUSION

This study identified five volunteer constraining factors for university sport students. Three out of the five identified factors are classified as intrapersonal constraints with two factors classified as structural in light of the Leisure Constraints Model. The absence of interpersonal constraining factors indicates a need for further research to clarify this occurrence. The possibility of utilising a different instrument, which is better designed with the Leisure Constraints Model in mind, could render evidence that is more relevant. The relatively high percentage of non-volunteerism amongst this group of sport students together with the predominance of intrapersonal and structural constraining factors may be an indication of a lack of understanding of the value of and opportunities to volunteer at community-based organisations.

Volunteer organisations could utilise the findings of the current study to communicate information more accurately that would endeavour to overcome both structural and intrapersonal constraints and encourage more sport students to engage in volunteering. Recruitment programmes of sport events and community organisations aimed at university sport students should be specific to their needs and should include information on the positive effects and outcomes that can be derived from volunteering at future work-related organisations.

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