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INFLUENCE OF PHYSICAL FITNESS PARAMETERS ON RELATIVE AGE EFFECT ON AMATEUR SECONDARY SCHOOL RUGBY UNION PLAYERS

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ABSTRACT

At the onset of puberty, boys experience great changes in growth and development. As such, boys who differ in age even by less than 12 months display significant differences in size, strength, power and skill levels and is known as Relative Age Effect (RAE). This study attempted to determine the prevalence of RAE in secondary school male rugby players in South Africa and to determine if RAE was related to physical fitness parameters. Two hundred and eighty-one (281) 13- to 16-year-old players from secondary schools ranked within the top 100 rugby playing schools in South Africa were sampled. Participants completed an RAE questionnaire and 11 rugby-specific physical fitness assessments. Results indicated that RAE was present in all groups. Only the under-15 age group demonstrated a significant ($p \leq 0.05$) *relationship between stature (p=0.010), hand-grip strength (p=0.000) and upper-body muscle endurance (p=0.049 [Q1 vs. Q2], p=0.037 [Q2 vs. Q3]) and RAE. Physical and physiological parameters not responsible for RAE in these age groups and a multidimensional evaluation considering not only physical and physiological parameters, but also technical, tactical and psychological parameters should be utilised to determine the reasons for RAE in secondary school rugby in South Africa.*

Keywords: Adolescent boys; Rugby; Fitness characteristics; Maturation; Relatively older athletes; Secondary school.

INTRODUCTION

During the onset of puberty, children experience great changes in biological growth and development leading to increases in both the body mass and stature, which may affect the performance of athletes (Stang & Story, 2005; Ford *et al*., 2012). Furthermore, adolescent children experience changes in neurological functioning that may have an impact on motor skill acquisition, control of both fine and gross motor skills, neurological improvements and cognitive function. In addition, there is also a great increase in the release of insulin-like growth factors (IGFs), as well as growth and steroid-sex hormones, which principally drive the process of increased bone and muscle maturation (Ford *et al*., 2012). These changes result in children who differ in age even by less than 12 months having significant physiological differences in size, strength, power and skill levels. This effect is better known as Relative Age Effect (RAE) (Del Campo *et al*., 2010) and means that relatively older athletes are frequently over-represented in elite teams with simultaneous under-representation of the younger individuals in the same age category (Hancock *et al*., 2013).

PURPOSE OF RESEARCH

Most of the research on RAE has focused on male athletes participating at an elite level of team sports, and more specifically, soccer. Despite this large body of research investigating RAE in elite sports, such as soccer, little research has been conducted on RAE in rugby union either at an elite or amateur level. The implications of this lack of research are that an unknown loss of potential talent in amateur sports, especially during the development phase, may exist due to RAE. As such, RAE must be identified in all sporting codes in order to minimise the loss of athletes. This is especially important in youth sports to allow for a larger pool of athletes to continue participating in a given sport. This may allow for enhanced adult and professional sport where the effects of maturation and associated physical parameters have disappeared and all athletes have reached full maturation and can compete on an equal footing. This supposition was previously demonstrated in England when Cobley *et al*. (2008) identified the presence of RAE among amateur school rugby players.

Cobley *et al*. (2008) propose that the physical demands of the sport itself might be a possible reason for RAE, since rugby may rely more on maturation-related attributes, such as strength, power and endurance, than on the skills of the athletes. In rugby union, the physical demands of the sport might be a possible reason for RAE since rugby union is characterised by frequent episodes of high-intensity running, sprinting, passing and tackling, interspersed with short recovery periods and longer periods of lower-intensity work demanding a high level of aerobic fitness (Walsh *et al*., 2011; Krüger & Smit, 2012).

A number of studies have identified the following anthropometrical and physiological characteristics as important components in rugby union, and as such may affect RAE, namely body mass, stature, body fat percentage (BF%), body mass index (BMI), muscle endurance, speed, acceleration, muscle strength, muscle power and aerobic capacity (Duthie *et al*., 2003, Gabbett *et al*., 2011; Garcia *et al*., 2014). Although unverified, Sedeaud *et al*. (2011) and Fuller *et al*. (2013) propose that increases in the body mass and stature of rugby players might provide an added advantage of generating and tolerating greater impacts, as well as providing strength and power during the phases of rucks, scums and mauls. This too may result in RAE, especially at youth level. However, higher levels of body fat in rugby players may lead to a decreased work rate and poor tackling ability (Duthie *et al*., 2003; Shaw *et al*., 2010; Smart *et al*., 2011).

Since rugby union consists of repeated low-intensity activities, interspersed with short bursts of high-intensity activities, it is important that rugby union players have a high anaerobic capacity (Chee, 2013), another physical component affected by maturation. Speed is a fundamental skill that needs to be developed specifically to maintain the pace of an intermittent sport and is thus important in rugby, as a rugby player requires good speed and acceleration for defensive and attacking playing periods in a match (Krüger & Smit, 2012). On the other hand, in rugby union strength and power (which are highly influenced by maturation and hormonal levels) are required in the execution of tackles, to gain and retain possession of the ball during the contact situation and for explosive accelerations (Duthie *et al*., 2003). When aerobic capacity, as a physical fitness parameter influenced by maturation, is considered, previous research has demonstrated that rugby players with high aerobic fitness are able to perform more high-intensity efforts during a match than those with lower levels of this type of fitness because of the influence of the aerobic system on recovery (Scott *et al*., 2003). Since relatively older athletes tend to demonstrate superior ability in the previously mentioned physical fitness parameters due to normal physiological growth and development, these athletes may be selected more frequently to join more competitive teams and strengthen the RAE in that sport (Te Wierike *et al*., 2014). In light of the above, the present study aimed (a) to determine the prevalence of RAE in amateur secondary school male rugby players in South Africa and (b) to investigate if RAE may be influenced by rugby-specific physical fitness parameters.

METHODOLOGY

Participants

Two hundred and eighty-one (N 281), 13-to 16-year-old rugby union players from six secondary schools in the Gauteng Province, South Africa, ranked within the top 100 rugby playing schools in South Africa, were invited to participate in the study (South African School Sports, 2015). Groups were further subdivided into age category groups, according to the athlete's date of birth (under (U)/14 [n=111], U/15 [n=98] and U/16 [n=72] years). Purposive sampling was used and all participants were free from relative and absolute contraindications to exercise testing.

Assessment tools

The RAE questionnaire which gathered birth date distribution data was administered to the participants. The calendar start date of 1 January was used for all annual age categories. The annual age categories were then coded into birth date quartiles (Q), corresponding to the selection year and beginning with the relatively older quartiles: Q1=1 January to 31 March; Q2=1 April to 30 June; Q3=1 July to 30 September; Q4=1 October to 31 December, respectively. The participants' birth month data was compared to the birth month data of the general Gauteng Province population in order to determine if a difference existed between the expected number of participants born in a birth quartile and the observed effect. The participants were also required to complete 11 rugby-specific physical fitness assessments (Jenkins & Reaburn, 2000; Coopoo & Govender, 2002; Heyward, 2006; Castro-Pinero *et al*., 2009). The physical fitness assessments consisted of anthropometric, speed, maximal strength, muscle endurance, anaerobic capacity and aerobic capacity assessments.

Anthropometrical assessments

Anthropometry is the science of measurements applied to the human body and generally includes measurements of body mass, stature and selected body and limb girths. These are key components of an individual's health and physical fitness profile (Harman & Pandorf, 2000). Anthropometric measurements were carried out according to the methods proposed by the International Society for the Advancement of Kinanthropometry (ISAK) (Norton & Olds, 1996) and measured by the same technician. The following anthropometrical assessments were administered: body mass, stature, BMI, girth measurements, skinfold thickness and BF%. These anthropometrical assessments are widely used when assessing the body composition of adolescents, but available data on the reliability of these assessments are controversial. The girth measurements of the participants were measured at the following sites: relaxed upper arm, chest, waist, gluteal (hip), mid-thigh and medial calf. Furthermore, skinfold thickness was measured at the participant's chest, abdominal, thigh, triceps, axilla, subscapular and supra-iliac skinfold. Body fat percentage was calculated using the equation of Slaughter *et al*. (1988), namely Body fat %=1.21 {triceps + subscapular} – 0.008 {triceps + subscapular}^{2} – 5.5. A limited number of body fat percentage equations for adolescent children have been developed and the Slaughter *et al.* (1988) equation has been shown to be valid and most accurate when measuring body fat percentage as a group value for adolescent children as was done in the present study (Rodriguez *et al.*, 2005).

Maximal strength assessment

Hand-grip strength was assessed to determine the maximum isometric strength of the hand and forearm muscles using a handgrip dynamometer (Jamar hand-grip strength calliper Warrenville, Illinois, United States of America) (Heyward, 2006). Time constraints due to availability of participants led to the adaptation of the testing battery and as such, the 1-RM bench press assessment was not included in the testing battery.

Speed assessments

The 10 metre and 35 metre (m) sprint assessments have been indicated to provide a good index of a participant's sprint ability specific to the distances typical to rugby (Jenkins & Reaburn, 2000). The best time of two attempts after the participant had completed the 10m- and the 35m-sprints served as final score.

Muscle endurance assessments

The 60-second (sec) sit-up assessed the abdominal muscle endurance of the participants (Castro-Pinero *et al.*, 2009). In addition, the 60-second push-up was used to assess the upper-body muscle endurance of the participants (Heyward, 2006).

Anaerobic capacity assessment

The 250-metre shuttle run test was utilised to evaluate the anaerobic capacity of the participants (Coopoo & Govender, 2002).

Aerobic capacity assessment

Aerobic capacity can be defined as the ability to deliver oxygen to the muscles, as well as utilising it effectively in order to generate energy to support muscle activity during exercise (Armstrong *et al.*, 2011). The present study utilised the multistage fitness test to provide a valid estimate of maximal aerobic capacity (VO_2max) (Jenkins & Reaburn, 2000). The final score of the multistage fitness test was utilised to calculate the predicted VO_2 max of the Silva *et al.* (2012) demonstrate that there is a significant correlation between the multistage fitness test and predicting the VO_2 max of adolescent Portuguese children when using the following equation (Leger *et al.*, 1988), namely Predicted VO_2 max (ml.kg^{-1}.min^{-1}) = 31.025 + 3.238(speed) – 3.248(age) + 0.1536(age)(speed).

Ethical clearance

An ethical clearance application to conduct the study was submitted to the Institutional Review Board at the University of Johannesburg. Clearance was granted and the following clearance number was allocated to the research, REC-01-259-2015.

Statistical analysis

A Chi-squared goodness-of-fit test was used to examine the differences between observed and expected birth date distributions of all participants. Descriptive and exploratory statistical analyses were employed to test for normality and equality of variance. Means and standard deviations, independent t-tests, a one-way Analysis of Variance (ANOVA) and a Kruskall-Wallis test were used to determine if any differences existed between the groups. P-values ≤0.05 were considered statistically significant in the interpretation of the results. There was no individual data analysis, rather group trends were reported. A statistical computerised package, Statistical Package for the Social Sciences (SPSS) (IBM SPSS 22.0), was used to compute the data.

RESULTS

Table 1 demonstrates the birth date distribution data per age group category and compares the birth date distribution data to that of the general provincial population. In this regard, the findings of the present study demonstrated that the quarterly birth date distribution of all the age groups (U/14, U/15 and U/16) differed significantly (p≤0.05) from the general provincial population. Specifically, the Chi-squared goodness-of-fit test indicated an over-representation of relatively older athletes and an under-representation of relatively younger athletes in the U/14 age group (χ^2=21.72, p=0.000), the U/15 age group (χ^2=15.06, p=0.002) and the U/16 age group (χ^2=11.03, p=0.012). The finding demonstrated that RAE was prevalent in school-aged male rugby union players in the Gauteng province.

***Table 1*. DIFFERENCE BETWEEN BIRTH QUARTILES OF PARTICIPANT RUGBY PLAYERS WITHIN EACH AGE GROUP**

		Birth Quartile					
Groups	**N**	Q1	Q2	Q3	Q4	χ^2	p
U/14							
Sample (n)	111	47	24	27	13	21.72	0.000*
	%	42.34%	21.62%	24.32%	11.71%		
U/15							
Sample (n)	98	39	27	18	14	15.06	0.002*
	%	39.80%	27.55%	18.37%	14.29%		
U/16							
Sample (n)	72	26	24	13	9	11.03	0.012*
	%	36.11%	33.33%	18.06%	12.50%		

*Significant difference (p≤0.05) between birth quartiles
U/14=Under 14 age group U/15=Under 15 age group U/16=Under 16 age group
Q1=Birth quartile one Q2=Birth quartile two Q3=Birth quartile three Q4=Birth quartile four
N: Population group n: Sample group.

The one-way ANOVA test revealed no significant difference ($p>0.05$) between the physical fitness parameters of relatively older athletes and relatively younger athletes in either the U/14 or U/16 age groups (Table 2). However, the one-way ANOVA test indicated significant ($p\leq0.05$) differences for stature ($p=0.010$) and hand grip-strength ($p=0.000$) between relatively older athletes and relatively younger athletes in the U/15 age group.

Table 2. **RUGBY-SPECIFIC PHYSICAL FITNESS PARAMETER VALUES FOR AGE GROUPINGS OF RUGBY PLAYERS**

	U/14			U/15			U/16		
Parameter	n	M±SD	p	n	M±SD	p	n	M±SD	p
Body mass	89	67.45±13.23	0.499	71	75.90±13.26	0.453	35	89.91±17.09	0.306
Stature	89	1.72±0.06	0.169	71	1.75±0.06	0.010*	35	1.80±0.08	0.658
BMI	89	22.76±4.26	0.578	71	24.68±4.10	0.859	35	27.66±4.76	0.512
Relaxed upper arm	88	30.18±3.03	0.800	71	32.10±3.61	0.724	35	34.90±3.29	0.542
Chest	89	89.25±8.64	0.441	71	93.72±7.96	0.460	35	101.39±9.16	0.151
Waist	88	79.26±10.96	0.671	71	83.61±11.70	0.590	35	89.73±12.36	0.606
Gluteal	89	92.22±11.05	0.964	71	98.62±9.12	0.829	35	105.74±10.41	0.211
Mid-thigh	88	50.05±5.88	0.904	71	52.61±6.04	0.437	35	56.52±6.72	0.178
Medial calf	87	37.04±3.63	0.548	71	39.38±6.29	0.494	35	40.72±3.89	0.235
Sum of skinfolds	89	69.70±41.32	0.175	71	79.61±43.14	0.984	35	88.61±41.23	0.731
Fat %	89	13.87±8.06	0.554	71	15.55±8.13	0.978	35	18.86±8.69	0.693
Hand-Grip Strength	89	43.90±7.58	0.427	71	49.61±7.76	0.000*	35	56.20±6.12	0.188
10m-sprint	85	2.31±0.16	0.761	68	2.24±0.16	0.559	31	2.25±0.16	0.560
35m-sprint	85	5.76±0.47	0.703	68	5.62±0.44	0.394	31	5.52±0.37	0.608
60sec-push-ups	86	29.51±11.55	0.543	69	29.26±10.53	0.076	33	33.79±14.07	0.361
60sec-sit-ups	87	34.44±7.80	0.608	69	35.20±8.64	0.190	33	35.09±9.30	0.919
Multistage fitness test	86	7.32±1.66	0.351	63	7.44±2.26	0.790	29	7.25±1.97	0.109
Estimated VO_2max	86	47.55±4.56	0.494	63	46.99±6.86	0.795	29	44.14±5.68	0.174

*Significant difference ($p<0.05$) between birth quartiles M=Mean SD=Standard deviation
Fat %=Fat percentage VO_2max=Maximum oxygen consumption

Although the one-way ANOVA test did not indicate any significant difference in the 60sec-push-up values in the U/15 age group, the Independent t-test demonstrated significant differences between birth quartile one and two (p=0.049), as well as between birth quartile one and three (p=0.037). In addition, the difference between birth quartile one and birth quartile four was not significant, but the effect size was small (p=0.071). Furthermore, the Independent t-test demonstrated significant differences between birth quartile one and four (p=0.004) for stature as well as significant differences between birth quartile one and two (p=0.024), one and three (p=0.013) and one and four (p=0.000) in hand-grip strength.

DISCUSSION

The study attempted to determine the prevalence of RAE in amateur secondary school male rugby players in South Africa, as well as to explore if RAE was influenced by rugby-specific physical fitness parameters. The findings of the present study demonstrated that an uneven birth date distribution exists in amateur U/14, U/15 and U/16 secondary school male rugby players in South Africa. These findings are supported by Delorme and Raspaud (2009) who demonstrated that RAE was present in French elite rugby players. In this regard, their study indicated that 27.17% of the athletes were born in the first birth quartile, compared to 18.50% born in the fourth birth quartile. It is important to note that the population age group categories include in the latter study differ significantly from those in the present study. As such, generalisation of these findings to those of the present study should be made with the utmost caution.

The findings by Till *et al*. (2010) more closely resemble that of the present study, since their study demonstrated a significant RAE in U/14, U/15 and U/16 rugby league players in the United Kingdom. Their study reported that 33.09% of the U/14 athletes representing the community rugby squad were born in the first birth quartile, compared to 19.96% born in the fourth birth quartile. Furthermore, within the U/15 age group, 28.47% of the athletes were born in the first birth quartile, compared to 20.55% in the fourth birth quartile and 30.89% of the U/16 athletes were born in the first birth quartile, compared to 19.75% of athletes in the fourth birth quartile. In light of these findings, it is reasonable to conclude that RAE plays a significant role in the selection processes of macro-schools in South Africa.

When the rugby-specific physical fitness parameters are considered, no significant difference was observed between birth quartiles in either the U/14 or U/16 age groups. In contrast, the U/15 age group demonstrated a significant difference in stature, hand-grip strength and upper-body muscle endurance between birth quartiles, with relatively older athletes demonstrating superior values. Interestingly, previous studies have also demonstrated contrasting results, with some studies indicating significant differences in physical fitness parameters between birth quartiles while other studies indicated no significant difference (Delorme & Raspaud, 2009; Gil *et al*., 2013; Till *et al*., 2014; Wattie *et al*., 2014; Fragoso *et al*., 2015). It must be mentioned that these previous studies assessed different team sports than that of the present study.

When considering the U/14 and U/16 age groups in the present study, the findings demonstrate that physical fitness parameters do not have an influence on the presence of RAE and cannot be considered as a possible reason for the RAE in the U/14 and U/16 age groups. In contrast, the findings of the U/15 age group indicate that the RAE observed in this sample group could be due to either superior stature, hand-grip strength and/or upper-body muscle endurance in the relatively older athletes and can be considered as a possible reason for RAE in that sample group. This superiority in stature, hand-grip strength and upper-body endurance might have provided the relatively older athletes with an advantage in match-related activities, such as forcefully taking the ball from the opposition in a tackle or maintaining a strong position in the ruck once the player had released the ball or turned over possession (Smart *et al*., 2011). This will provide an advantage to relatively older athletes in the game of rugby and may have resulted in superior performances by these athletes and, as a consequence, these athletes may have been selected into the A- and B-squads. Furthermore, in contrast the relatively younger athletes may have been overlooked for selection in the A-and B-squads due to their weaker physical fitness parameters.

Given the apparent challenges arising from annual age-groupings, several recommendations have been proposed to resolve RAE. Firstly, the present study proposes introducing body mass categories as selection criteria in youth rugby. A competition structure of this type will take the form of age categories based on skeletal age spanning 3-4 years and will incorporate a set of body mass categories within each age category. In such a competition structure, athletes with similar physiological maturity will participate together, resulting in fair competition for both relatively younger and older athletes. As a result, this might lead to the reduction or possible disappearance of RAE in rugby union (Albuquerque *et al*., 2012). Delorme (2013) is in agreement and proposes that introducing body mass categories into sports may reduce RAE, since the physiological advantages experienced by relatively older athletes will be the same as for relatively younger athletes.

One must remain cautious, however, since it will be difficult to integrate this system into a well-established school-rugby system, such as in the case of South Africa and the value from this system with regards to RAE are as yet unsubstantiated. A second recommendation based on the findings of the present study would be to change the current age-grouping system, which assigns an athlete to a specific age group based on the athlete’s birth date in a calendar year. Giacomini (1999) proposes that athletes be allowed to participate in a specific age-group category until one month prior to their birth date. As a result, an athlete may start participation in a squad as a relatively younger athlete, but will end as a relatively older athlete.

While the present study provides some insight and awareness into possible reasons for the presence of RAE in youth rugby and, as such, the responsibility of coaches and conditioning specialists to implement strategies to minimise the RAE and ensure that all youth rugby players receive equal and fair opportunities to succeed in the sport, the findings of study should be viewed within the context of its limitations. One such limitation is the relatively small sample size in the U/16 age group and, thus, one should be careful to generalise the findings to other population groups.

PRACTICAL APPLICATION

If possible, future research on RAE should consider evaluating the anthropometrical characteristics of pre-adolescent athletes at the start of their rugby participation. Research of this type might demonstrate that talent identification systems, employed by the coaches during the early participation years of the athletes, tend to discriminate in favour of physically stronger athletes and may confuse maturation for talent. In addition, the athletes who are considered physically stronger, are in the majority of cases athletes born in the early part of the year (Helsen *et al*., 2005). This creates a selection bias where relatively younger athletes are left out of more competitive teams that results in a stronger RAE in rugby union. It might also be beneficial for future research to compare rugby-specific physical fitness parameters between A, B, C and D-squads of the same macro-school. Research of this type may determine if a significant difference exists between the physical fitness parameters in these squads and if so, which physical fitness parameters have an influence on the selection processes employed by coaches and conditioning specialists.

CONCLUSIONS

Coaches and conditioning specialists must strive towards the equal development of skills and physical attributes of both relatively older athletes and relatively younger athletes. If this is not achieved, the strength of RAE in youth sport will increase further and the loss of potentially talented athletes will become more severe.

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REFERENCES

ALBUQUERQUE, M.R.; LAGE, G.M.; DA COSTA, V.T.; FERREIRA, R.M.; PENNA, E.M.; MORAES, L.C.C. & MALLOY-DINIZ, L.F. (2012). Relative age effect in Olympic taekwondo athletes. *Perceptual and Motor Skills*, 114(2): 461-468.

ARMSTRONG, N.; TOMKINSON, G.R. & EKELUND, U. (2011). Aerobic fitness and its relationship to sport, exercise training and habitual physical exercise during youth. *British Journal of Sport Medicine*, 45(11): 849-858.

CASTRO-PINERO, J.; GONZÁLEZ-MONTESINOS, J.L.; MORA, J.; KEATING, X.D.; GIRELA-REJÓN, M.J.; SJÖSTROM, M. & RUIZ, J.R. (2009). Percentile values for muscle strength field tests for children aged 6 to 17 years: Influence of weight status. *Journal of Strength and Conditioning Research*, 23(8): 2295-2310.

CHEE, R. (2013). "Rugby union requirements for maximum energy output!" Hyperlink: [http://www.bodybuilding.com/fun/improve-rugby-union conditioning.htm]. Retrieved on 29 May 2013.

COBLEY, S.; ABRAHAM, C. & BAKER, J. (2008). Relative age effects on physical education attainment and school sport representation. *Physical Education and Sport Pedagogy*, 13(3): 267-276.

COOPOO, Y. & GOVENDER, A.N. (2002). Analysis of demands and the establishment of norms for U-21 South African provincial rugby players. *African Journal for Physical, Health Education, Recreation and Dance*, 8(1): 61-74.

DEL CAMPO, D.G.D.; VICEDO, J.C.P.; VILLORA, S.G. & JORDAN, O.R.C. (2010). The relative age effect in youth soccer players in Spain. *Journal of Sport Science and Medicine*, 9(2): 190-198.

DELORME, N. (2013). Do weight categories prevent athletes from relative age effect? *Journal of Sport Science*, 32(1): 16-21.

DELORME, N. & RASPAUD, M. (2009). The relative age effect in youth French basketball players: A study on the whole population. *Scandinavian Journal of Medicine and Science in Sport*, 19(2): 235-242.

DUTHIE, G.M.; PYNE, D.B. & HOOPER, S.L. (2003). Applied physiology and game analysis of rugby union. *Sports Medicine*, 33(13): 973-991.

FORD, P.R.; COLLINS, D.; BAILEY, R.; MACNAMARE, A.; PEARCH, G. & TOMS, M. (2012). Participant development in sport and physical activity: The impact of biological maturation. *European Journal of Sport Science*, 12(6): 151-526.

FRAGOSO, I.; MASSUCA, L.M. & FERREIRA, J. (2015). Effect of birth month on physical fitness of soccer players (Under-15) according to biological maturity. *International Journal of Sports Medicine*, 36(1): 16-21.

FULLER, C.W.; TAYLOR, A.E.; BROOKS, J.H.M. & KEMP, S.P.T. (2013). Changes in stature, body mass and age of English professional rugby players: A 10-year review. *Journal of Sport Science*, 31(7): 795-802.

GABBETT, T.J.; JENKINS, D.G. & ABERNETHY, B. (2011). Relationship between physiological, anthropometrical and skill qualities and playing performance in professional rugby league players. *Journal of Sport Science*, 29(15): 1655-1664.

GARCIA, M.; MARTINEZ-MORENO, J.M.; REYES-ORTIZ, A.; MORENO-ARRONES, L.S.; GARCIA, A. & GARCIA-CABALLERO, M. (2014). Changes in body composition of high competition rugby players during the phases of regular season; influence of diet and exercise load. *Nutricion Hospitalaria* (trans.: *Hospital Nutrition*), 29(4): 913-921.

GIACOMINI, C.P. (1999). Association of birthdate with success of nationally ranked junior tennis players in the United States. *Perceptual and Motor Skills*, 89(2): 381-386.

GIL, S.M.; BADIOLA, A.; BIDAURRAZAGA-LETONA, I.; ZABALA-LILI, J.; GRAVINA, L.; SANTOS-CONCEJERO, J.; LEKUE, J.A. & GRANADOS, C. (2013). Relationship between the relative age effect and anthropometry, maturity and performance in young soccer players. *Journal of Sports Sciences*, 32(5): 479-486.

HANCOCK, D.J.; STE-MARIE, D.M. & YOUNG, B.W. (2013). Coach selections and the relative age effect in male youth ice hockey. *Research Quarterly for Exercise and Sport*, 84(1): 126-130.

HARMAN, E. & PANDORF, C. (2000). Principles of testing selection and administration. In T.R. Baechle & E.W. Earle (Eds.), *Essentials of strength training and conditioning* (6th ed.) (pp.275-317). Champaign, IL: Human Kinetics.

HELSEN, W.F.; VAN WINCKEL, J. & WILLIAMS, A.M. (2005). The relative age effect in youth soccer players across Europe. *Journal of Sport Science*, 23(6): 629-636.

HEYWARD, V.H. (2006). *Advance fitness assessment and exercise prescription.* Champaign, IL: Human Kinetics.

JENKINS, D. & REABURN, P. (2000). Protocols for the physiological assessment of Rugby Union players. In C.J. Gore (Ed.), *Physiological tests for elite athletes: Australian Sport Commission* (2nd ed.) (pp.327-333). Champaign, IL: Human Kinetics.

KRÜGER, P.E. & SMIT, R.F. (2012). Physiological demands during rugby union match and practice session. Unpublished master's thesis. Pretoria, South Africa: University of Pretoria.

LEGER, L.A.; MERCIER, D.; GADOURY, C. & LAMBERT, J. (1988). The multistage 20 metre shuttle run test for aerobic fitness. *Journal of Sport Science*, 6(2): 93-101.

NORTON, K. & OLDS, T. (Eds.) (1996). *Anthropometrica: A textbook of body measurement for sports and health courses*. Sydney, Australia: University of New South Wales Press.

RODRIGUEZ, G.; MORENO, L.A.; BLAY, M.G.; BLAY, V.A.; FLETA, J.; SARRIA, A. & BUENO, M. (2005). Body fat measurement in adolescents: Comparison of skinfold thickness equations with dual-energy X-ray absorptiometry. *European Journal of Clinical Nutrition*, 59(10): 1158-1166.

SOUTH AFRICAN SCHOOL SPORTS (2015). "Rugby: The top 100 rankings SA school sports". Hyperlink: [www.saschoolsports.co.za/rugby/rugby-the-2013-top-100-rankings.html]. Retrieved on 1 September 2014.

SCOTT, A.C.; ROE, N.; COATS, A.J.S. & PIEPOLI, M.F. (2003). Aerobic exercise physiology in a professional rugby union team. *International Journal of Cardiology*, 87(2-3): 173-177.

SEDEAUD, A.; MARC, A.; SCHIPMAN, J.; TAFFLET, M.; HAGER, J. & TOUSSAINT, J. (2011). How they won rugby world cup through height, mass and collective experience. *British Journal of Sport Medicine*, 46(8): 580-584.

SHAW, B.S.; SHAW, I. & MAMEN, A. (2010). Contrasting effects in anthropometric measures of total fatness and abdominal fat mass following endurance and concurrent endurance and resistance training. *Journal of Sport Medicine and Physical Fitness*, 50(2): 207-213.

SILVA, G.; OLIVEIRA, N.L.; AIRES, L.; OLIVEIRA, J.M.J. & RIBEIRO, J.C. (2012). Calculation and validation of models for estimating VO_2max from the 20-m shuttle run test in children and adolescents. *Archives of Exercise in Heath and Disease*, 3(1-2): 145-152.

SLAUGHTER, M.H.; LOHMAN, T.G.; BOILEAU, R.A.; HORSWILL, C.A.; STILLMAN, R.J.; VAN LOAN, M.D. & BEMBEN, D.A. (1988). Skinfold equations for estimation of body fatness in children and youth. *Human Biology*, 60(5): 709-723.

SMART, D.; HOPKINS, W.G.; QUARRIE, K.L. & GILL, N. (2011). The relationship between physical fitness and game behaviours in rugby union players. *Journal of Sport Science*, 14(1): 8-17.

STANG, J. & STORY, M. (2005). Adolescent growth and development. In J. Stang & M. Story (Eds.), *Guidelines for adolescent nutrition services* (1st ed.) (pp.1-8). Minneapolis, MN: University of Minnesota Press.

TE WIERIKE, S.C.M.; ELFERINK-GEMSER, M.T.; TROMP, E.J.Y.; VAEYENS, R. & VISSCHER, C. (2014). Role of maturation timing in selection procedures and in the specialisation of playing position in youth basketball. *Journal of Sports Science*, 33(4): 337-345.

TILL, K.; COBLEY, S.; WATTIE, N.; O'HARA, J.; COOKE, C. & CHAPMAN, C. (2010). The prevalence, influential factors and mechanisms of relative age effect in UK rugby league. *Scandinavian Journal of Medicine and Science in Sport*, 20(2): 320-329.

TILL, K.; COBLEY, S.; O'HARA, J.; COOKE, C. & CHAPMAN, C. (2014). Considering maturation status and relative age in the longitudinal evaluation of junior rugby league players. *Scandinavian Journal of Medicine and Science in Sport*, 24(3):569-579.

WALSH, M.; CARTWRIGHT, L.; CORISH, C.; SUGRUE, S. & WOOD-MARTIN, R. (2011). The body composition, nutritional knowledge, attitudes, behaviours and future educational needs of senior schoolboy rugby players in Ireland. *International Journal of Sport Nutrition and Exercise Metabolism*, 21(5): 365-376.

WATTIE, N.; TIETJENS, M.; SCHORER, J.; GHANBARI, M.; STRAUSS, B.; SEIDEL, I. & BAKER, J. (2014). Does relative age influence motor test performance of fourth grade pupils? *European Physical Education Review*, 20(3): 398-406.

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