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Is Physical Activity Predictable From Age, Gender, Anthropometric Measures and Motor Abilities: Cross-Sectional Design in 8-12 Years-Old Children

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Abstract: *This study analysed the level of motor ability possessed in 8 to 12 year old children and determined which factors among age, gender, anthropometric measurements and MA components are useful predictors of physical activity levels (PA). A total of 256 children (128 boys and 128 girls) 3 year groups: year 4 (age 9.3 ± 0.3 years), year 5 (age 10.3 ± 0.3 years) and year 6 (age 11.3 ± 0.3 years) volunteered to participate at this study. Objective measurement of habitual PA was conducted by using an accelerometer for four days: two week days and two weekend days. MA tests included the flamingo balance test (FBT), eye-hand coordination (EHC), sit and reach (Sit-R), standing vertical jump (SVJ), hand grip (HG), sit-up, 30m dash, and figure of 8 agility (F8A) and 20m shuttle run test (20m SRT). Results showed that no significant differences were observed in school year, body mass, height and BMI between males and females, whereas percent body fat was higher in females than in males in all three year groups. A main effect of school year was found in EHC and HG in all three years while the significant differences between years 4 and 5 and 5 and 6 were observed in SVJ, 30m dash and sit-up tests. FBT was only significant between year 4 and 6. Sit and reach, F8A and 20m SRT tests did not change between the three year groups. A main effect for gender was found in all MA test results. Age and gender explained 20.3% and 11.6% of the Sedentary PA and light PA variances, respectively while body mass explained 7.6% and 5.5% of moderate PA and moderate and vigorous PA variances, respectively. MA components appear to be independent of the PA levels and gender, age and body mass seem to be the best predictors of PA in the studied population.*

Key Words*: Pediatric population, accelerometer, body composition, health.*

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I. Introduction

Modern day living has increased the amount of leisure time available to children and adolescents. However, this extra time has led to children engaging in an increased amount of sedentary activities (Hoos, Gerver, Kester, & Westerterp, 2003) rather than physical activity. Furthermore, studies have shown that motor abilities of both children and adolescents have actually decreased in recent years (Janssen & LeBlanc, 2010; Kretschmer, 2001) and this may be linked to an increase in sedentary activities including watching TV and computer use. On the other hand, participating in regular physical activity has been reported to be associated with health benefits for children and adolescents (Janssen & LeBlanc, 2010; Andersen et al., 2006). These health benefits include maintenance of a healthy weight over time, increased bone mass, low blood pressure and enhanced psychosocial outcomes (Bea, Blew, Howe, Hetherington-Rauth, & Going, 2016; Janssen & LeBlanc, 2010; Ortega, Ruiz, Castillo, & Sjostrom, 2008).

As a child grows, the body undergoes a gradual progression of steps; from general to specific motor performance (Katzmarzyk, Malina, & Beunen, 1997). Improvements in motor ability occur, and may lead to increases in physical activity performance. Stodden et al. (2008) suggested that in young children, physical activity may help improve motor skills, but as children get older, motor skills may affect participation in physical activity. Consequently, promoting regular participation of physical activity to children and adolescents, which incorporates motor functioning activities, is seen as an important factor that may increase the probability of individual participation in physical exercise in future (Andersen et al., 2006, Venetsanou & Kambas, 2017). However, it is still unclear which factors determine the level of physical activity participation in children and adolescents. One essential influencing factor may be the level of mastery of motor abilities which children and adolescents need in order to participate in different physical activities (Okely, Booth, & Patterson, 2001). A low level of MA tends to cause children to participate in more sedentary physical activities as a result of their motor problems (Faught, Hay, Cairney, & Flouris, 2005; Okely et al., 2001), whereas having a high MA level may promote participation in more physical activity (Haga, 2009). Furthermore, children who have decreased activity due to low MA may continue to be much less active in the future compared with those with higher MA (Haga, 2008).

Thus the level of motor ability could be an indication of how physically active someone is. However, in younger children, only a weak relationship existed between fundamental movement skills and PA levels monitored during a weekend in 3 - 4 year old Finnish children (Sääkslahti et al., 1999). Interestingly, this is further supported by McKenzie et al. (2002) who showed that MA including balancing, catching and jumping were not able to predict the physical activity level in children between the ages of 4 to 12 years. However, fundamental motor ability is considered to be the basis on which movement skills are founded and is required for normal participation in physical activity (Cohen, Morgan, Plotnikoff, Barnett, & Lubans, 2015; Kyle et al., 2012). Thus, it is reasonable to presume that there is likely to be a relationship between an individual's level of motor ability and their participation in physical activities. Further studies therefore need to be undertaken to examine the general concept of children's motor abilities and how they may be related to PA level and how MA components could predict future participation in PA (McKenzie et al., 2002).

On the other hand, measurement of body stature and mass is considered to be one of the most widely used indicators of growth whereas chronological age has been shown to be the strongest predictor of motor ability components when the inter-relationship between the body size, skeletal maturity, strength and motor ability components were assessed in 7 - 12 year old American children (Katzmarzyk et al., 1997). Interestingly, studies have shown that body mass index (BMI) and body composition are two of the main factors that affect motor abilities during childhood and adolescence; especially with movements in which the body is projected, supported off the ground and moved with high-speed (Malina et al., 1995; Raudsepp & Pääsuke, 1995). However, there is limited research in this area. Furthermore, the increase in BMI may exist due to lower PA as a consequence of lower MA. Kyle et al. (2012) reported that for boys and girls with high level of adiposity, those with higher level of physical activity display a significantly higher motor performance score.

To date, there are very few controlled studies that have investigated the link between BMI, MA and PA in 8 - 12 year old children. Further, if MA is a determinant of individual physical activity, it could be that improvements in MA are a viable strategy to promote increased physical activity in youth with potential health gains.

The aims of this study were therefore to a) analyse the level of MA possessed in 8 to 12 year old children, b) determine which factors among age, gender, anthropometric measurements and MA components are useful predictors of physical activity levels.

II. Methods

II-1. Subjects:

Participants were recruited from a local primary school in the UK. This was a cross-sectional designed study with data collected from 256 participants from 3 year groups: year 4 (age 9.3 ± 0.3 years), year 5 (age 10.3 ± 0.3 years) and year 6 (age 11.3 ± 0.3 years). Children and their parents were informed beforehand about the objectives and scope of the project, the procedures, risks, and benefits of the study and gave their written consent. The present study was conducted according to the Declaration of Helsinki and the protocol was fully approved by the Institutional research ethics committee of ASSIX University. All participants completed all motor ability tests, anthropometric measurements and physical activity measures. 139 participants met the criteria of a minimum of three measured days and 10 hours/day which was used in physical activity analysis. A total number of 175 participants from all three years completed a 20m shuttle run test (20m SRT).

II-2. Measurement of physical activity

Objective measurement of habitual physical activity was conducted by using an accelerometer (ActiGraph GT1M, ActiGraph LLC, Fort Walton Beach, FL). All participants were asked to put on the accelerometer right side of the hip in the morning and take it off before bed-time. The accelerometers were set to record data at a 5s epoch. The

participant's activity was monitored continuously for four days; two week days and two weekend days. Periods with 0 counts lasting 10 min or longer were considered times that the Actigraph was not worn and were removed from the data file. Physical activity raw data from the ActiGraph accelerometer was downloaded to a PC using the ActiGraph software 3.2. Then the ActiGraph Analysis Tool v3.00 software was used to assess the individuals' exact time spent at each PA level using the accelerometer cut-off points that had been defined previously (Al-Hadabi & Hadj Sassi 2018).

II-3. Anthropometry

Standing height and body mass were measured. Body mass index ($kg.m^{-2}$) was calculated for each subjects. Skinfold thickness was assessed at the triceps and calf in triplicate at each site to the nearest 0.1 mm using a Harpenden calliper. The average of the three values was calculated and converted to percent body fat using the following formula (0.735 x sum of skinfold) +1 and (0.610 x sum of skinfold) +5 for male and female, respectively (Lohman, Roche, & Martorell, 1988).

II-4. Measurement of motor abilities

Motor ability measurements were conducted according to European test of Physical fitness (Eurofit) as they have been shown to have scientific validity, reliability and objectivity (Adam, Klissouras, Ravazzolo, Renson, & Tuxworth, 1988). The measurements session started with a short warm up (6 minutes), followed by motor ability tests including the flamingo balance test (FBT), eye-hand coordination (EHC), sit and reach (Sit-R), standing vertical jump (SVJ), hand grip (HG), sit-up, 30m dash, and figure of 8 agility (F8A). Maximal aerobic power was assessed by using the 20m SRT as described by Léger & Lambert (1982). VO_2max was predicted using the equation provided by Léger, Mercier, Gadoury, & Lambert (1988) . All tests were administered in the sports hall and school playground at the same time of the day.

II-5. Data handling and statistical analysis

All motor ability test scores were calculated according to each test instruction. Descriptive statistics were calculated for all anthropometric measurements, MA tests and time spent in sedentary (SPAL), light (LPAL), moderate (MPAL) and vigorous physical activity levels (MVPAL). Then a two-way between groups ANOVA was conducted to explore the impact of three different school year groups and gender on motor ability. Tukey post hoc and independent sample t-tests were carried out if a significant main effect was identified. To allow a direct comparison in aerobic capacity (20m SRT) to groups with the same age and gender, an individual age and gender specific z-score was calculated following the formula obtained by Olds, Tomkinson, Léger, & Cazorla, (2006). A z-score above zero is indicative of a higher performance whereas a z-score below zero indicates a lower performance than the mean average score of participants of the same age and gender. Stepwise multiple regressions were used to assess how well age, gender and anthropometric measurements are able to predict MA components. Additionally, stepwise multiple regressions were used to assess whether MA components and/or anthropometric measurements were the dominant components to explain PA levels.

III. Results

III-1. Anthropometric characteristics

A summary of the participant age and anthropometric characteristics is shown in table 1. Height, body mass, BMI and body fat percentage (BF%) increased with school year ($P < 0.05$). However, there were no significant differences in school year, body mass, height and BMI between males and females ($P > 0.05$), whereas BF% was higher in females than in males in all three year groups ($P < 0.05$).

Table 1. Mean ± SD participant age and anthropometric descriptive characteristics

	Year 4		Year 5		Year 6	
	elaM (n=38)	Female (n=48)	elaM (n=42)	Female (n=41)	elaM (n=48)	Female (n=39)
Age (yr)	9.3±0.3	9.3±0.3	10.3±0.3†	10.2±.3†	11.3±.03†‡	11.2±0.4†‡
Height (m)	1.4±0.1	1.4±0.1	1.4±0.1†	1.4±0.1†	1.5±0.1†‡	1.5±0.1†‡
Body mass (kg)	31.8±6.0	32.3±6.3	35.7±7.5†	37.3±9.2†	40.4±8.6†‡	41.7±9.9†‡
BMI ($kg.m^{-2}$)	16.8±2.3	17.2±2.4	17.0±3.7†	18.3± 3.4†	18.4±2.8†‡	18.8±3.6†‡
BF (%)	17.8±7.6	21.1±5.4*	18.6±7.2†	23.4±6.6$^{\dagger *a}$	20.2±6.7†‡	24.9±8.7$^{\dagger\ddagger *a}$

† indicates significantly different from year 4; ‡ indicates significantly different from year 5, * indicates significantly different between genders, **a** indicates gender specific significant difference from year 4 ($p < 0.05$).

III-2. MA test results for both genders in years 4, 5 and 6.

Table 2 shows the mean ± SD of the participant MA scores. FBT, EHC, SVJ, HG, 30m dash and sit-up tests improved with increasing school year ($P < 0.05$). A main effect of school year was found in EHC and HG in all three years ($P < 0.05$) while the significant differences between years 4 and 5 and 5 and 6 were observed in SVJ, 30m dash and sit-up tests. FBT was only significant between year 4 and 6 ($P < 0.05$). Sit and reach, F8A and 20m SRT tests did not change between the three year groups ($P > 0.05$).

A main effect for gender was found in all MA test results ($P < 0.05$). EHC was higher in males than in females in all three years ($P < 0.05$). Year 4 females performed better than males in the same year group at FBT and sit-reach, and year 5 females also had greater 20m SRT (VO_2 max) values than males at the same school year ($P < 0.05$). However, year 4 males were significantly better at sit-up and F8A tests than females, which was also true for year 6 males who were additionally better at the 30m dash. Year 5 males outperformed females at the 30m dash as well as HG and SVJ tests.

Table 2 Mean ± SD of the participant descriptive characteristics (years 4, 5 and 6) at different MA test results over a three year cross section study.

	Year 4		**Year 5**		**Year 6**	
	Male	Female	Male	Female	Male	Female
FBT (step downs)	6.3±2.8	4.3±3.0*	4.4±3.61	4.0±3.0	4.3±3.3†	3.1±3.2†
EHC (catches of ball)	14.6±5.5	8.5±4.5*	16.7±5.3†	9.4±3.9†*	19.1±5.6†‡ a b	13.0±3.9†‡* a
Sit R (cm)	17.5±6.0	19.9±4.5*	16.7±6.9	19.4±5.8	17.0±7.3	19.6±5.6
SVJ (cm)	26.0±5.2	24.8±4.1	27.0±5.5	24.3±5.4*	29.0±5.0†‡	27.0±5.2†‡
HG (kg)	13.1±2.9	12.5±2.6	16.3±3.5†	14.4±3.5†*	17.8±3.8‡	17.1±3.2†‡
30 m Dash (s)	5.4±0.3	5.6±0.4*	5.3±0.4	5.5±0.4	5.1±0.4†‡	5.3±0.4†‡*
Sit-Ups (number performed)	17.3±4.3	16.1±4.2	18.8±4.4	16.3±4.6*	21.1±6.0†‡	18.4±4.4†‡*
F8A (s)	33.1±4.0	35.4±4.2*	33.1±5.1	32.9±4.5	31.4±4.7	34.4±4.6*
VO_2max ($ml.min^{-1}.kg^{-1}$)	50.3±3.4	50.0±3.0	48.1±3.2	51.2±4.3*	50.5±4.2	49.7±3.2
20 SRT (z score)	0.48±0.7	1.05±0.8*	0.66±0.8	0.56±0.9	0.42±0.8	1.07±0.7*

† indicates significantly different from year 4; ‡ indicates significantly different from year 5; * indicates significant gender difference at the same year; **a** indicates gender specific (males) significant difference from year 4; **b** gender specific (females) significant difference from year 5 (P < 0.05). **FBT**: flamingo balance test, **EHC**: eye-hand coordination test, **Sit-R**: sit and reach test, **SVJ**: standing vertical jump test, **HG**: hand grip test, **F8A**: figure 8 agility test, **20m SRT**: 20m shuttle run test.

III-4. PA levels by gender and year group

Table 3 shows the mean ± SD of time (minutes) spent at sedentary physical activity level (SPAL), light physical activity level (LPAL), moderate physical activity level (MPAL), vigorous physical activity level (VPAL), and moderate and vigorous physical activity levels (MVPAL) in years 4, 5, and 6 ($P > 0.05$). There was no year group difference ($P > 0.05$). However, a significant gender effect on LPAL only was found, with LPAL higher in males in year 6 compared to their female counterparts ($P < 0.05$).

Table 3 Mean ± SD of the time (minutes) spent in different physical activity level in children in years 4, 5 and 6.

	Year 4		**Year 5**		**Year 6**	
	Male	Female	Male	Female	Male	Female
SPA	562.2±73.5	595.8±65.4	561.3±76.0	601.4±66.5	582.6±68.9	613.0±48.6
LPA	171.5±48.8	160.9±44.0	156.2±50.1	150.1±50.5	179.6±55.5	133.5±33.8*
MPA	2.3±4.3	2.2±4.0	3.7±3.9	4.2±6.6	4.0±5.0	3.2±5.7
VPA	1.2±1.7	1.0±1.0	1.0±1.7	1.0±1.7	0.4±0.6	0.3±0.8
MVPA	3.5±4.2	3.0±4.6	4.4±5.3	5.1±7.2	4.4±5.2	3.5±5.9

* indicates significant difference from males ($P < 0.05$). SPA: sedentary physical activity, LPA: light physical activity, MPA: moderate physical activity, VPA: vigorous physical activity, MVPA: moderate &vigorous physical activity

III-5. Regression coefficients of the different physical activity levels related to MA tests

The relationship of different PA levels to MA tests was explored by stepwise multiple regression. None of the MA tests were able to predict SPAL and VPAL.

EHC was the only MA test that was able predict LPAL, with EHC being able to explain 7.4% ($p < 0.01$) of the variance of LPAL.

In MPAL and MVPAL, HG was able to explain 6.7% ($p < 0.01$) and 5.0% ($p < 0.01$) of the variance respectively.

No other MA tests were able to predict any other PA levels.

III-6. Regression coefficients of the different physical activity levels related to anthropometric measurements, age and gender

In terms of determining whether the anthropometric measures can explain different PA levels, stepwise multiple regressions showed that gender explained 6.4% ($p < 0.01$) of the variance of SPAL, which could be increased by inclusion of BF% 5.0% ($p < 0.01$). Gender also explained 3.4% ($p < 0.01$) of the variance of LPAL.

None of the anthropometric measurements were able to explain any of the MPAL, VPAL and MVPAL variances.

III-7. Regression coefficients of the different physical activity levels related to both MA tests and anthropometric measurement variables

When both MA tests and anthropometric measures were included to assess how they could explain different PA levels, multiple regression analysis indicated that gender explained 16.6 ($p < 0.01$) of the SPAL variance, which could be increased by inclusion of age to 20.3% ($p < 0.01$).

Again in LPAL, gender was able to explain 6.8% ($p < 0.01$) of the variance, which increased to 11.6% ($p < 0.01$) by the addition of age.

In MPAL and MVPAL, body mass was the only anthropometric measure that explained 7.6% ($p < 0.01$) and 5.5% ($p < 0.01$) of the variances, respectively, whereas in VPAL, age explained 7.0% ($p < 0.01$) of the variance.

IV. Discussion

There is a growing recognition that normally children, between the ages of 5 and 7 years, become mechanically active and coordinated in basic motor performance (Malina, Bouchard, & Bar-Or, 2004; Gallahue, 1995). Where these fundamental motor abilities (MAs) tend to be refined by practising and learning where the quality and quantity improve and they become integrated into more difficult motor skills during middle childhood to be used then in many sports (Haga, 2008; Malina et al., 2004). The current cross-sectional study aimed to firstly analyse the level of MA possessed in 8 to 12 year old children. Secondly, it aimed to determine whether age, gender, anthropometric measurements and MA components are useful predictors of physical activity levels.

In order to measure each MA component, a number of tests have been selected to measure different and specific MA components in children and adolescents. These tests have often been administrated to children as they have been shown to have scientific validity, reliability and objectivity (Adam, Klissouras, Ravazzolo, Renson, & Tuxworth, 1988).

Over the last decade, there has been evidence that children's growth is almost linear (Rogol, Roemmich, & Clark, 2002). The study results showed that in this age group, both genders' height, body mass, BMI and body fat percentage (BF%) increased with school year ($P < 0.05$) with no significant differences between gender apart from BF%. These results are similar to the findings in previous studies (Wells, 2007). However, the significant increase of the females' BF% compared to males was clear from the previous studies of Wells (2007), Arfai et al. (2002) and Milanese, Bortolami, Bertucco, Verlato, & Zancanaro (2010), and has been attributed to a gain in body weight. On the other hand, the lower BF% in males might also be due to the type of PA in which males normally participate, as PA levels are generally lower in females compared to males at any given age (Nader, Bradley, Houts, Mcritchie, & O'brien, 2008).

IV-1. General MA performance

The main results from this study illustrated that MA components improved with school year apart from sit and reach, agility and 20m SRT tests which remained the same with increasing school year. The study also showed that MA components depend mainly on school year and to a lesser degree on gender.

The eye-hand coordination and static strength were the only MA components that were affected by school year in all three years. The improvement of the other MA components had been noticed in some school years but not in all. One reason for this could be the overlapping between participants' ages at each school year and/or having quite a large standard deviation, making the differences between school years less clear. The continuous development of strength ability as measured by HG, SVJ and sit-up tests could be interpreted as a result of growth and development of the nervous and hormonal systems and anthropometric factors (Davis et al., 2005; Zavaleta & Malina, 1982). Strength is considered to be one of the essential components of MA and is improving at around this age group of children as a result of the development of the nervous system, where the connection between the tip of the nerve and the muscle is increasing with growth (Lambertz, Mora, Grosset, & Perot, 2003: Oliver & Smith, 2010). This improves the efficiency of neuromuscular system in recruiting more muscle tissues to produce more power. In eye-hand coordination ability, where eyes can be guided to follow movement of the hands, both genders showed improvements with age. The reason behind this result may be the development in the neuromuscular system and its functional improvement and growth as well as the use of different senses such as the sense of sight and hearing along with the sense used to estimate the joints' place (Oliver & Smith, 2010; Lambertzet al. 2003).

Improvements with speed ability (faster times) were found as school year increased. The speed ability development required a level of muscle strength. It is likely that the increase in muscle strength (especially in the lower body) that was reported in the current study has led to improvements in the length of the step to achieve a high rate of frequency (Dintiman & Ward, 2003). Moreover, speed ability improves with school year as there is growth and improvement of the nerve cells, improving conductance down the nerves to allow a faster rate of muscle contraction (Oliver & Smith, 2010; Lambertzet al. 2003).

For balancing ability, the illustrated improvement over the three year groups could be due to cumulative motor experiences, which contributed to improving the efficiency of spindle fibres, especially in the strings and Golgi tendon organ (Baechle, Earle, & Wathen, 2000). These motor experiences play a key role in determining first the pressure on the joints and second the status of the body in the spaces which allow the child to maintain his or her balance (Baechle et al., 2000). In addition, muscle strength is considered to be an important factor in maintaining equilibrium (Davis et al., 2005). However, another study showed a reduction in balancing ability with age when static standing was measured at 6, 8, 10 and 24 years old (Rival, Ceyte & Olivier, 2005).

This study revealed that no significant changes in flexibility, agility and 20m SRT abilities have occurred with increasing school years. These results could be interpreted as flexibility being an inherited trait, more than an acquired result of training or an effect of environmental factors (Marshall & Bouffard, 1998). Furthermore, flexibility depends, in particular on the muscle elongation of each joint and its elastic component. Therefore, unlike the other components, flexibility needs training in order to improve and develop with increasing age (Baechle et al., 2000).

Agility as an ability requires a quick change in body direction, with a good level of both speed and dynamic balance abilities (Malina et al., 2004). Whilst this group of children revealed a good speed development with time, the obtained level of dynamic balancing ability over time may be the main factor affecting the development of agility in this specific group of children.

The observed steady level of 20m SRT performance among this group of children over the three school years was converse to the results from Stratton et al., (2007) in 9-11 year old British children, which showed a reduction in fitness level over time. It has been suggested by a previous cross-sectional study that both genders tend to decrease their cardiorespiratory level throughout childhood (Rowland, 2005), as children's movements tend to be more spontaneous and they appear to engage in very short bouts of activity compared to adults (Bailey et al., 1995; Armstrong & Welsman, 2006). However, participants in the current study confirmed a good level of fitness among 8-12 year old children, which leads us to speculate that the type of activities in which children normally participate play an important role in maintaining fitness levels over time.

IV-2. Gender MA performance

Males outperformed females in eye-hand coordination ability over all three years, whereas young females (year 4) showed better performance at balance and flexibility than the respective group of same year males. The increased EHC in males compared to females in all school years could be a result of males generally participating in more eye-hand coordination activities than females (Bjorklund & Brown, 1998). In particular, males are involved more in activities such as playing football, throwing and catching balls, climbing trees, or playing on gymnastic equipment, which allows a superior development of their coordination ability (Bjorklund & Brown, 1998). However, information on this aspect was not taken during this study. In a previous study, when training was given to both 9 year old males and females to improve their throwing ability in order to develop their coordination, interestingly females improved following training and their throwing performance was slightly better than that of males, although not significantly so (Thomas, 1994). This suggests that females can be trained and that enhancing physical activity by encouragement is one way to reduce the difference between genders (Krombholz, 1997).

The increased improvement in year 5 males compared to females in HG and SVJ tests and 20m SRT could be mostly due to the fact that males had a similar body mass but lower BF% than females over all three school years. Increased speed performance was demonstrated in year 5 and 6 males in comparison with the respective groups of same year females, as seen during the 30m dash test. This outcome could be due to the fact that males have been shown to have better lower body muscle strength. This result has been supported by Raudsepp & Pääsuke's 1995 study, which reported that males by the age of 8 tended to run faster than females, by $0.1 m.s^{-1}$ to $0.3 m.s^{-1}$.

Consistent with Armstrong & Welsman (2002), who reported that males tend to have a better performance in 20m SRT than females, this study's results showed that only year 5 male's outperformed females in this test. According to the current study's results, where year 5 males showed a better performance than females at strength and speed abilities in this age group, this could lead to a higher fitness level for this school year. Whiles females tend to reach their greatest improvement in aerobic endurance from age 11 to 13 years old according to the studies of Rowland (2005). At that stage the level of growth and maturation plays a role in their fitness level development.

Young females (year 4) had better performance than males at the same school year in balance and flexibility tests. Previous studies have shown the same results reported by Malina et al. (2004) and Rival et al. (2005). It is likely again that the nature of physical play activities females normally engage in and the motor experiences gained during these activities could contribute to the development of balancing ability in young females to a greater extent than in young males. It is interesting however, that this difference is no longer apparent by years 5 and 6.

Similarly, year 4 females were also more flexible in this study, with the effect disappearing in the older age groups. This is contrary to previous findings, where females tended to have increased flexibility at all ages in comparison with males (Malina et al., 2004). Lower back, hip and upper thigh flexibility in females is shown to be stable between the ages of 5 and 8 years old and then it begins to increase throughout adolescence up to the age of 15 years old (Malina et al., 2004). The higher standard deviation in this study could be a contributing factor as to the lack of a significant difference between both genders' performance at older age groups.

IV-3. PA performance

No significant differences were found between any of the PA levels (i.e. SPA, LPA, MPA, VPA and MPVA). This was also irrespective of school year. At Year 5, females appear to have spent a greater time at MPA than their male counterparts, but there is a large spread of data which suggests that some females are very active whereas others tend to become more sedentary. By Year 6, overall, females tended to be less active although the only difference found was that Year 6 females were significantly less active at LPA than males. Previous studies on similar aged children only report MPA, VPA and MVPA (i.e. no SPA or LPA) and consistently show greater PA at these higher intensities in males compared to females. It is suggested that males tend to play more vigorously in free play than girls at all ages (Sallis, Buono, Roby, Micale, & Nelson, 1993; Troiano et al., 2008) but gender only affected LPA in the current study. This could be because studies use different methods to measure PA levels. Previous studies using accelerometry have used different types of accelerometers (uniaxial or triaxial) which can lead to various interpretations of PA levels. Furthermore, diversity in existing thresholds of particular intensities reduces the comparability between studies. Previous studies have calibrated accelerometer counts and defined cut-off points in a laboratory environment in young people (Freedson, Pober, & Janz, 2005; Treuth et al. 2004). These studies have determined thresholds in a very controlled laboratory environment, which is likely to alter the validity of the thresholds. Some of the studies have included free-living activities in young children, but these are still under controlled laboratory environments (Freedson et al., 2005; Treuth et al. 2004).

These thresholds have been determined using a different age group, for instance adolescents, to determine thresholds (Treuth et al., 2004), whereas others have used a wide range of ages (Freedson, Melanson, & Sirard, 1998; Freedson et al., 2005). In the current study, the thresholds that were used to analyse PA intensity levels were based on a similarly aged group of children (Al-Hadabi & haj Sassi, 2019). The data was collected in a free lifestyle environment where the participants were asked to engage in particular activities. This allowed the thresholds to be specific for this age of children and to have more ecological validity. Moreover, Bailey et al. (1995) demonstrated that 6-10 year old children were engaged for 77.1% of the time in low intensity PA and only 3.1% in high PA intensity. These results confirm that children normally participate in short sporadic bouts of activity (Bailey et al., 1995). For that reason, the epoch length should be considered carefully when children's PA is measured (Trost, 2007). Studies that have used a one minute epoch reported some possible underestimation of the vigorous and high PA intensities under both field and laboratory environmental conditions (Nilsson, Ekelund, Yngve, & Sjostrom, 2002; Rowland 2007). Therefore, in children, using as short a time interval (epoch) as 5 seconds may in practice be required to capture their very short and rapidly changing movements (Armstrong & Welsman, 2006; Bailey et al., 1995; Freedson et al., 2005). The differences in time interval (epoch) when used to measure PA levels in children could be a barrier when comparing study outcomes and epoch length should therefore always be stated.

IV-4. Effects of anthropometric measures and MA components on PA levels

Looking at MA components and their possibility of being a predictor of PA levels, the current cross sectional study found that EHC predicted 7.4% of the variance of LPAL where HG tests were able to predict MPAL and MVPAL and explain 6.7% ($p < 0.01$) and 5.0% ($p < 0.01$) of variances of these levels, respectively. This shows that children who have a better EHC and HG performance tend to spend more time participating in LPA, MPAL and MVPAL compared to those children with a lower level of performance.

Barnett, Morgan, van Beurden, Ball, & Lubans, (2011) found that motor skill proficiency (kick, catch, and overhand throw) explained 11% of variance in MVPA but the strength of the pathway between locomotor proficiency (hop, side gallop, and vertical jump) and MVPA was not significant, meaning that object control proficiency was responsible for the variance explained in MVPA in 215 adolescents (mean age: 16.4 ± 0.6 years). It must be emphasized, however, that time spent in MVPA was 848.68 ± 553.39 $min.week^{-1}$ that is much lower than values reported in the current study. This difference could be due to the fact that physical activity has been assessed by using the Adolescent Physical Activity Recall Questionnaire whereas in the present study it was objectively measured by accelerometer. Age group may also explain this difference. Morgan, Okely, Cliff, Jones, & Baur (2008) reported that for boys object control skills (strike, dribble, catch, kick, overhand throw, and underhand roll) explained 10% of variance to vigorous physical activity whereas for girls neither object control skills nor locomotor skills (run, gallop, hop, leap, horizontal jump, and slide) were significant predictors of physical activity in 5-9-year obese children. The lack of agreement between current data and those reported by previous studies could be due to the categories of age studied and the variety of methods employed to measure both motor skills and physical activity.

On the other hand, anthropometric measures may be better in predicting PA levels where gender and BF% were able to explain 6.4% and 5.0% ($p < 0.01$) of the variance of SPAL, respectively. Whereas gender found to be the only factor explained 3.4% of the variance in LPAL. These results were earlier confirmed that females showed a greater BF% than males. This could be a reason of females being insufficiently active, and spent a large amount of time in SPAL. In this context, Kyle et al. (2012) reported that PA was not significantly correlated with percent body fat in 6- to -8 year-old Danish children but was significantly correlated with motor performance in boys but not girls. Furthermore, they found that boys and girls with higher physical activity had significantly higher motor performance than boys and girls with lower physical activity. When both MA tests and anthropometric measures were included to assess how they could explain different PA levels, none of the MA components was able to predict any of the PA levels. However, gender and age were shown to be the dominant factors for predicting SPAL, LPAL and MPAL whereas body mass was the only predictor of both VPAL and MVPAL. Dubose, K. D., McMillan A.G., Wood A. P., & Sisson S. B. (2018) suggested that weight status mediate the relationship between PA and specific motor skills in children aged 3 to 10 years.

V. Conclusion

In summary, results of the current study showed that both genders demonstrated a development in height, body mass, BMI and body fat percentage (BF%) with increasing school year, where BF% was shown to always be greater in females. The study also showed that MA components mainly depend on school year and to a lesser degree on gender. MA components improved with school year apart from sit and reach, agility and 20m SRT tests, which remained the same with increasing school year. Despite the fact that previous studies have shown negligible differences between genders before the age of 11, the current study found that males outperformed females in eye-hand coordination ability over all three years, whereas young females (year 4) showed better performance at balance and flexibility than the respective groups of same year males.

In terms of monitoring PA levels, this study illustrated that no significant differences were found between any of the PA levels (i.e. SPA, LPA, MPA, VPA and MPVA). School year was also not a significant factor; only Year 6 females were found to be significantly less active at LPA than males. To determine whether MA components themselves and/or anthropometric measurements are useful predictors of physical activity levels, the results demonstrated that none of the MA components was able to predict any of the PA levels. However, gender, age and body mass were shown to be the dominant factors in predicting SPAL, LPAL, MPAL, VPAL and MVPAL. Therefore, by using a longitudinal design method, children can be tracked over time to see how they change from year to year. This can overcome the age overlap problem that is seen within cross-sectional studies.

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