Investigation into the relationship between adolescents' perceived and actual fundamental movement skills and physical activity

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Abstract

Objectives: To explore the relationship between fundamental movement skill (FMS) competence, perceived FMS competence and physical activity (PA) in adolescents.

Methods: The Test of Gross Motor Development (TGMD), the TGMD-2 and the Victorian Skills manual were used to assess FMS competence (locomotor, object control and stability). The Physical Self Confidence scale was used to assess perceived FMS competence (locomotor, object control and stability). Moderate to vigorous intensity PA (MVPA) was measured via accelerometry. Multi-level modelling analyses was used to examine: (i) actual FMS as the predictor and perceived FMS as the outcome, (ii) perceived FMS as the predictor and MVPA as the outcome, and (iii) actual FMS as the predictor and MVPA as the outcome. All analyses were completed for each subtest of FMS (locomotor, object control and stability).

Results: A total of 584 adolescents (boys n = 278) aged 12.82 – 15.25 years (M 13.78, SD .42) participated in this study. Actual stability was associated with perceived stability ($p<.01$) and MVPA ($p<.05$) in boys. This was not found true for girls, however actual locomotor skills were associated with MVPA ($p\leq.05$). Boys scored significantly higher than girls for FMS proficiency, perceived FMS and MVPA ($p<.05$).

Discussion: Gender differences may exist due to cultural gender differences in sport participation norms. Considering the magnitude of physical and psychological changes occurring during adolescence, it is recommended to track young people over time to better understand the relationship between perceived and actual FMS, as well as PA participation.

Keywords: physical activity, motor competence, adolescents

Introduction

Fundamental movement skills (FMS) are basic skills that are used in every-day life, and as such the mastery of these skills among children and adolescents is an important contributor to future participation in sports and physical activity (PA) (O'Neill, Pfeiffer, & Williams, 2008). Children should achieve FMS mastery by the age of 10 (Gallahue, Ozmun, & Goodway, 2012). It has been reported however that children and adolescents are falling below the expected FMS proficiency levels for their age group (Hardy, Barnett, Espinel, & Okely, 2013; Mitchell et al., 2013; O' Brien, Belton, & Issartel, 2015) which may affect their sports specific skill development and as a result, their PA participation (Gallahue et al., 2012; Robinson, Logan, Webster, Getchell, & Pfeiffer, 2015).

FMS can be broken down into subtests of skills, these subtests are locomotor, object control and stability skills (Burton & Miller, 1998). When assessing FMS, particularly in a mixed-gender sample, it is important to look at these skill subtests separately, as individuals and genders may vary across skill types. When Barnett et al. (2010) examined the correlation between gender and FMS on boys and girls aged 10-16 years, they found that a significant percentage of boys reached mastery or near mastery levels for object control FMS compared to girls however, there were little or no differences between genders in the locomotor skills. This was also found to be the case in O' Brien et al. (2015), where Irish boys aged 12-13 years performed object control skills significantly better than girls, but no significant difference between the genders was found in terms of locomotor performance.

A previous review highlights a strong positive relationship between FMS and PA in both children and adolescents (Lubans, Morgan, Cliff, Barnett, & Okely, 2010). It is reported that adolescents who are currently physically active are more likely to continue this type of behaviour into adult life, which may contribute to a healthy lifestyle and can also help reduce the incidence of chronic diseases such as heart disease and lung cancer (Hallal, Victora, Azevedo, & Wells, 2006). The majority of children and adolescents are not achieving the recommended guidelines of at least 60 minutes of moderate to vigorous PA (MVPA) per day to achieve health benefits from being active (Belton, O' Brien, Meegan, Woods, & Issartel, 2014; Belton et al., 2016; Currie, Zanotti, De Looze, Roberts, & Barnekow, 2012; Woods et al., 2010).

As stated by Welk and Eklund (2005), physical self-concept has been shown to influence a variety of health-related behaviors and outcomes such as PA. Conceptual and theoretical associations exist between physical self-concept and various motivational theories of physical activity. For example, in competence motivation theory (Harter, 1982), perceptions of competence are considered important predictors of voluntary behaviours such as PA. As Welk and Eklund (2005) suggest, research on physical self-concept may be helpful in understanding PA behaviours. There are however, different dimensions to self-concept which include perceptions of personal behaviour in very specific situations such as performance of a skill or sports skill (Marsh, Trautwein, Lüdtke, Koller, & Baumert, 2006). Lirgg (1991) states that the perception of one's own abilities has been frequently cited as a psychological factor affecting athletic performance. Hence, when assessing PA and FMS among children and young people, it is also important to assess their perceived competence. During adolescence it has been found that perceived competence is positively associated with PA (Sallis, Prochaska & Taylor, 2000). Harter's model (1978) proposes that actual competence comes before perceived competence, which in turn affects motivation. Griffin and Keogh (1982) suggest that actual competence manipulates perceived competence which in turn influences the choices in PA participation (Griffin & Keogh, 1982a). According to Barnett, Morgan, Van Beurden and Beard (2008) "children who are skill proficient may develop a high perception of sport competence leading to greater participation in PA and higher fitness levels. Conversely, children with poor skill proficiency may develop low perceived competence resulting in less engagement in PA in adolescence" (p.2). The concept of perceived competence can also be conceptualized within the frame of Shavelson, Hubner, and Stanton (1976), as they state how a person acts may influence how they perceive themselves and their perceptions may influence how they act. Their perceptions are also affected by those around them as they may compare their abilities with that of their peers. Bandura (2006) states that feelings and beliefs of efficacy can vary in strength and this may affect a person's perseverance at performing a given task "Weak efficacy beliefs are easily negated by disconfirming experiences, whereas people who have a tenacious belief in their capabilities will persevere in their efforts despite innumerable difficulties and obstacles" (p. 313). The higher one believes in their ability at a given task/skill the greater they will persevere. This can in turn increase the possibility of the task/skill being performed successfully and then result in the person increasing in confidence (Bandura, 2006). Bandura (2006) also states that task specific confidence is a mediator for behavioural change therefore highlighting the importance of measuring this construct alongside PA. It is important that self-confidence is measured on a skill by skill basis as those who are confident at performing one skill may not feel confident at performing others (McAuley & Gill, 1983). Lirgg (1991) states that confidence has been operationalized in a number of ways. For example, the constructs of self-efficacy (Bandura, Adams, & Beyer, 1977), perceived competence (Harter, 1978) and movement confidence (Griffin & Keogh, 1982) have all been suggested as measuring a person's perception of their ability. Lirgg (1991) states that irrespective of the method by which it is measured, self-confidence has been shown as a significant variable that influences motor performance.

Stodden et al. (2008) highlights that youth with higher levels of actual and perceived motor competence, are more likely to be physically active, subsequently providing them with more opportunities to further develop confidence and proficiency in the performance of motor skills.

While Stodden's theoretical model (2008) has identified a positive relationship between perceived FMS, FMS proficiency and PA participation, this relationship has limited evidence among adolescents. Various studies have been conducted assessing the relationship between perceived FMS ability and actual FMS competence (De Meester et al., 2016; Raudsepp & Liblik, 2002). There have been studies highlighting the associations between actual FMS competence and PA among both children and adolescents (Barnett, van Beurden, Morgan, Brooks, & Beard, 2009; Holfelder & Schott, 2014; O'Brien, Belton, & Issartel, 2015), however, they have not included perceived FMS. There has also been a recent study assessing FMS and perceived FMS ability among adolescents (McGrane et al. 2016) which found that for boys there is no significant correlation whereas for girls there is a moderate significant correlation. This study also found that girls are less proficient at FMS than boys (McGrane et al., 2016) which is similar to findings from other studies among this age group (Hardy et al., 2013; O' Brien et al., 2015). The only studies to assess all three variables; PA, FMS and perceived FMS, have been completed among children (Barnett, Ridgers, & Salmon, 2015; Slykerman, Ridgers, Stevenson, & Barnett, 2016). From examining these associations there may be potential to predict PA behaviour from perceived motor competence which may in turn help identify those most at risk of low PA participation (Barnett et al., 2015). It is important to address this gap in the literature among adolescents as it is well known that this is a crucial period where PA participation tends to decrease (Hallal et al., 2012; Robinson et al., 2015).

The aim of this study was to investigate associations between adolescents' perceived and actual FMS competence and PA. A secondary aim was to explore sex differences in perceived FMS, actual FMS and MVPA.

Methods

Twenty-six schools were recruited from a variety of areas in County Dublin. Of these schools six dropped out before study commencement citing a variety of reasons, such as change of principal. One first year class from the 20 remaining schools was then recruited resulting in 603 participants. Informed assent for participation was granted by each participant and informed consent was granted from their parent/guardian resulting in 589 participants; all participants were free to withdraw from the study at any stage (four became injured and one withdrew). The total number of participants was 584. Full ethical approval for this study was granted by Dublin City University research ethics committee (DCUREC/2010/081).

Fifteen FMS were assessed during a regular physical education (PE) class at the participants' school. The Test of Gross Motor Development-2nd Edition (TGMD-2) (Ulrich, 2000) was used to assess 12 of these skills which were made up of six locomotor (run, hop, gallop, slide, leap and horizontal jump) and six object control skills (catch, kick, throw, dribble, strike and roll). The TGMD-2 was used as it "is a process-oriented measure with well-established reliability and validity where the performance criteria of each skill are assessed rather than the outcome or product of performance" (Barnett et al., 2015, p. 594). The remaining three skills comprised of the skip, and vertical jump (locomotor skills) which were assessed using the Test of Gross Motor Development (TGMD) (Ulrich, 1985), and stability which was assessed using the Victorian Fundamental Movement Skills Manual (Victoria, 1996). These skills were included as they were deemed relevant to the Irish sporting culture of gaelic games (O' Brien et al., 2015).

Consistent with the TGMD-2 protocol, and to ensure accurate measurement of the FMS, trained researchers demonstrated each of the skills once. Participants received a brief description of each skill. They then completed one practice go and two trials of each skill with no feedback given at any stage. All trials were accurately videoed with full body movement in view. These videos were then labelled and saved for later assessment. Prior to data analysis researchers were trained to assess these videos accurately with a minimum of 95% inter-rater and intra-rater reliability achieved by researchers. They then completed assessment of the skills as per TGMD-2 guidelines scoring a “1” if the component of the skills is present and a “0” if it is absent. For each FMS, the two test trials were added together to get the total score for each skill. Then the locomotor skills were summed to give a total locomotor score (maximum possible score of 66), object control skills were summed to give a total object control score (maximum possible score of 48), and balance was the only stability skill (maximum possible score of 10). This was similar to the procedures carried out in McGrane et al. (2016) which used the same selection of skills.

Participants’ perceived FMS competence was assessed using the physical self-confidence scale (McGrane et al. 2015). This tool has an excellent test retest reliability with an overall Intra Class Correlation r = 0.92. Content validity and concurrent validity were also good, with the scale achieving a correlation coefficient of r = 0.72 with the Physical Self Perception Profile (McGrane et al. 2015). The physical self-confidence scale consists of 15 questions in which participants rate their confidence at performing each of the 15 FMS and was developed to be used alongside the TGMD-2 specifically (McGrane et al. 2015). Participants rated their confidence at performing each skill on a likert scale of 1-10, “1” being not confident at all and “10” being very confident for example; “how confident are you that you can run in a straight line?”. The maximum perceived motor competence score which could be achieved was 150 if participants scored their confidence at 10/10 for performing all 15 skills. The questionnaire was administered during PE class after participants completed the FMS assessment with a ratio of tester to student 10:1.

Participants were asked to wear an Actigraph GT1M, GT3X, or GT3X+ accelerometer (Actigraph LLC, Pensacola, FL) for a period of nine days on their right hip beginning on the day they completed the FMS assessment. Vertical accelerations were used as these are comparable between the three models of Actigraph (Robusto & Trost, 2012). Accelerometers were set to record using a 10-sec epoch. The first and last day of accelerometer data were omitted from analysis to allow for subject reactivity (Esliger, Copeland, Barnes, & Tremblay, 2005). The minimum number of valid days required for inclusion in analysis was two weekdays (Kriemler et al., 2010). A number of strategies were employed to ensure compliance (Belton, Brien, Wickel, & Issartel, 2013): students were met in the morning of each school day to ascertain compliance with the wear instructions; an optional twice daily SMS reminder text was sent before school and in the afternoon; teachers in each school checked whether or not participants were wearing their monitors each school day; students were advised to place reminders to wear monitors in noticeable areas in their homes; a record card was provided for recording periods of non-wear; and students who were compliant with the wear-time inclusion criteria, entered a class draw for a €20 sports voucher (per class). In line with other studies, a day was deemed valid (and therefore included in the analysis) if there was a minimum of eight hours recorded wear time per day (Fitzgibbon et al., 2011). Monitor non-wear was defined as ≥20 consecutive minutes of zero counts (Cain, Sallis, Conway, Dyck, & Calhoon, 2013; O' Brien, Issartel, & Belton, 2013). Counts below zero and above 15,000 were excluded due to biological plausibility (Esliger et al., 2005; O' Brien et al., 2013). The mean daily minutes spent in MVPA was estimated using validated cut points for this age group: MVPA ≥2296 counts/min (Evenson et al., 2008).

Body mass (kg) and height (m) were directly measured using a SECA calibrated heavy-duty scale and a SECA Leicester Portable Height Measure. Weight status was calculated based on sex specific BMI cut points (Cole et al., 2000).

Data Analysis

All variables normality was assessed, and physical self-confidence was log transformed due to skewness. Independent sample t-tests were conducted to assess sex differences in actual FMS, perceived FMS and MVPA. Multi-level modelling analyses was used for each FMS subtest to examine: (i) actual FMS as the predictor and perceived FMS as the outcome, (ii) perceived FMS as the predictor and MVPA as the outcome, and (iii) actual FMS as the predictor and MVPA as the outcome. Multi-level analysis takes into account the hierarchical nature and clustering (Twisk, 2006). A 2-level data structure was used to account for the students nested within the schools; with students defined as the first level, and school defined as the second level of analysis to adjust for potential clustering at the school level. Regression coefficients for the outcome variables reflected the relationship between the predictor variable and outcome variable adjusted for baseline covariates: BMI and sex. Where these covariates were significant, stratified analysis for each modifier was conducted to identify where the significance lay. The Wald statistic was used to assess the significance of the regression coefficients in the main models. Analyses were performed using MLwiN 2.36 software (Centre for Multilevel Modelling, University of Bristol, UK). Statistical significance for all analysis was set at $p<0.05$ as suggested by Twisk (2006). All descriptive statistics presented were derived using IBM SPSS 23.

Results

A total of 584 adolescents (boys n = 278) aged 12.82 – 15.25 years (M 13.78, SD .42) participated in this study. All participants scored below the expected level of FMS proficiency for their age group (which would entail achieving the maximum score for all skills). For locomotor skills a mean score of 40.45 (SD=5.33) out of a possible score of 66 was achieved, for object control skills a mean score of 41.10 (SD=5.12) out of a possible score of 48 was achieved, and for stability a mean score of 5.65 (SD=3.61) out of a possible score of 10 was achieved (see Table 1). Girls had significantly poorer perceived ($p<.001$) and actual locomotor skills ($p<.001$), perceived ($p<.001$) and actual object control ($p<.001$), and perceived stability competence ($p<.05$) compared to boys (Table 1). Girls were found to have higher BMI levels than boys ($p<.01$). Boys participated in significantly more MVPA than girls ($p<.001$). After controlling for the covariates (BMI and sex), actual locomotor skills was associated with MVPA ($p<.05$). Sex was also significant in the analysis investigating the relationships between perceived FMS competence (Perceived Locomotor, Object Control, and Stability) and MVPA and likewise in the analysis between actual FMS (Actual Locomotor, Object Control, and Stability) and MVPA. Where sex was significant stratified analysis was conducted. When models were investigated by sex (Table 3), actual stability was associated with perceived stability ($p<.01$) and MVPA ($p<.05$) in boys. In girls' actual locomotor skills were associated with MVPA ($p\leq.05$).

Discussion

There has been very limited research examining the relationship between adolescents' actual and perceived FMS competence, and also any associations these variables may have with PA. As highlighted in the review by Barnett et al. (2016), PA is the most examined correlate of gross motor competence with many studies looking at the relationship between FMS and PA alone (Barnett et al., 2016; Holfelder & Schott, 2014; O'Brien et al., 2015), or actual FMS and perceived FMS alone (McGrane et al., 2016). The current study investigated the associations between adolescents' perceived and actual FMS competence and PA. This study found that for the total sample, actual locomotor competence was associated with MVPA ($p<.05$), although when this relationship was investigated separately by sex it was only significant for girls ($p<.05$). For boys, actual stability, perceived stability and MVPA were all associated ($p<.05$). There were sex differences present in each individual variable with girls scoring significantly lower for perceived competence, FMS and MVPA ($p<.05$). Girls also had a higher BMI than their male counterparts ($p<.05$). In addition, it was found that this cohort as a whole were underperforming their FMS levels for their age group.

This study only found an association between boys perceived stability, actual stability and MVPA ($p<.05$). There were no other significant associations found between perceived ability and actual FMS ability. This finding differs with a study by McGrane et al. (2016) which found a small significant correlation between actual FMS and perceived FMS overall ($r=0.219$) in this age group. It also goes against the theory that children will become more accurate at self-assessing their ability as they age (Harter & Pike, 1984). Supporting the current finding however, De Meester et al. (2016) did find that among adolescents actual and perceived motor competence were only moderately correlated. This may suggest that as children enter adolescence the accuracy of their perceptions of their ability changes. One plausible reason for this may be due to the increased awareness of social comparisons and importance of peers at this age, whereas during childhood young children have less inhibitions. This is supported by Shavelson et al.'s framework (1976) which highlights that self-concept is multifaceted and is influenced by environmental reinforcements, social acceptance, ability and significant others. The people with whom adolescents compare their own ability against has an effect on how they rate their own ability and their confidence at performing i.e. by being in a strong group your self-concept may be lower whereas by being in a weaker group your self-concept may be higher. Along the same line, seeing peers surpass your ability can cause a decrease in self-esteem and confidence in your ability. In contrast, seeing yourself gain proficiency and surpass your peers may strengthen self-esteem and confidence in ability, thereby resulting in enhanced performance attainments (Bandura, 1993).

Gender as a covariate in this study was significant in a number of models ($p<0.05$) (Table 2). When data for these models was split and analysed separately by gender, the association between perceived FMS, actual FMS and MVPA for individual subtest groups (locomotor, object control and stability) differed for boys and girls. In boys, actual stability was associated with perceived stability ($p<.05$) and MVPA ($p<.05$). Perceived stability was also associated with MVPA ($p<.05$) in boys. In girls, this was not the case however, actual locomotor skills were associated with MVPA ($p<.05$). In the study by McGrane et al. (2016) the correlation between actual FMS and perceived FMS also differed by sex, as it was not significant for boys but was for girls. In a previous study among adolescents looking at FMS competence and PA, no significant correlations were found for boys however, a significant correlation was found for vigorous PA in girls (O'Brien et al., 2015). Findings highlight the importance of considering sex when looking at the relationship between FMS (actual and perceived) and PA participation.

The lack of associations between actual FMS (for locomotor and object control subtests) and perceived FMS (for locomotor and object control subtests) found in this study when considering sex may be a result of the participants being behind the expected FMS development levels for their age (Table 1). Perhaps if adolescents can develop FMS competence this may result in them becoming more active, as they will possess the skills required to participate in sport and PA. Through this PA participation, their perceived competence may consequently increase, resulting in significant associations in the future. As discussed previously, Stodden et al. (2008) proposed a model that described this developmental dynamic and reciprocal relationship, as a "positive spiral of engagement". This model highlights youth with higher levels of actual and perceived motor competence, are more likely to be physically active, subsequently providing them with more opportunities to further develop confidence and proficiency in the performance of motor skills. This spiral of engagement would suggest that it may also be negative i.e. if someone is not competent at FMS they will not be active. However in this study only girl's actual locomotor skill was associated with their MVPA. This suggests that this spiral of engagement requires further investigation as the association between actual FMS, perceived FMS and PA participation may emerge overtime, which could potentially explain why it may be difficult to capture it in a cross-sectional study.

While participants generally were below expected FMS and PA levels for their age in the current study– (i.e. mastery level of all FMS (Gallahue et al., 2012) and at least 60min MVPA per day (World Health Organization, 2010)) - boys did score significantly higher than girls for FMS competence, perceived FMS competence and also MVPA. This supports the findings in a previous study among an adolescent population in which boys scored significantly higher than girls for FMS and perceived FMS (McGrane et al., 2016). As suggested in Barnett et al.'s review (2016), one plausible explanation for this may be due to maturation and biological factors. It is also possible that sex variations may be accredited to the individual sex differences in habitual PA and sports participation at this age (Barnett, van Beurden, Morgan, Brooks, & Beard, 2010; O' Brien et al., 2015). Van Beurden, Zask, Barnett, and Dietrich (2002) further reinforce this point in their study by pinpointing the participation in different sporting activities as the reason for differences between genders. Similar to the MVPA findings in this study, a recent study (Sutherland et al., 2016) in 12 year olds, highlighted that boys were more active (62.7 min of MVPA) than girls (46.6 min of MVPA). Belton et al. (2016) also found that boys accumulated significantly more MVPA than girls daily, on both weekdays and weekend days. It has been suggested that since girls achieve a lower level of mastery at FMS than males, that this may contribute to girls lower levels of PA (Hardy et al., 2013). As Barnett et al. (2016) highlights, boys receive more encouragement and opportunities in sport and PA than girls both at home, in school and in the community which provides them with more opportunity to develop their FMS.

Strengths and Limitations

The major strength of this study is that it assesses the association between perceived FMS and actual FMS proficiency using a comparable scale developed by McGrane et al. (2016) which was developed for this specific purpose for use with the TGMD-2 (Ulrich, 2000), the TGMD (Ulrich, 1985) and the Victorian Skills Manual (Victoria, 1996) as opposed to a general confidence scale. It is also the first study which assesses the three variables of perceived FMS, actual FMS and MVPA among this population covering all three subtests of FMS (locomotor, object control and stability). The main limitation of the study is that it only assesses these variables at one time point. The authors suggest that tracking these variables from childhood into adolescence would provide an even better insight into these variables and the complexity of their associations.

Conclusions

To conclude, when sex and BMI are taken into account, adolescents' actual locomotor and object control skills, perceived locomotor and object control skills and MVPA are not significantly associated. We know that adolescents are below the expected FMS developmental level for their age (McGrane et al., 2016; O' Brien et al., 2015) and that there are sex differences in performing FMS, with girls performing FMS significantly poorer than boys. It is suggested that girls poor performance at FMS can result in them being significantly less active than boys at this age group which can cause an increase in PA drop out (Hardy et al., 2013). For this reason, an intervention targeting girls of this age group is required to improve their FMS proficiency and their PA levels in order to bridge the gap between genders. Considering the magnitude of physical and psychological changes occurring during the adolescence period, it is recommended to track young people over time to better understand the relationship between perceived and actual FMS as well as PA participation.

Bandura, A. (1993). Perceived Self-Efficacy in Cognitive Development and Functioning. *Educational Psychologist*. http://doi.org/10.1207/s15326985ep2802_3

Bandura, A. (2006). Guide for constructing self-efficacy scales. *Self-Efficacy Beliefs of Adolescents*, 307–337.

Bandura, A., Adams, N., & Beyer, J. (1977). Cognitive processes mediating behavioral change. *Journal of Personality and Social Psychology, 35,* 125–139.

Barnett, L. M., Lai, S. K., Veldman, S. L. C., Hardy, L. L., Cliff, D. P., Morgan, P. J., … Barnett, L. M. (2016). Correlates of Gross Motor Competence in Children and Adolescents : A Systematic Review and Meta-Analysis. *Sports Medicine*. http://doi.org/10.1007/s40279-016-0495-z

Barnett, L. M., Morgan, P. J., van Beurden, E., & Beard, J. R. (2008). Perceived sports competence mediates the relationship between childhood motor skill proficiency and adolescent physical activity and fitness: a longitudinal assessment. *The International Journal of Behavioral Nutrition and Physical Activity, 5,* 40. http://doi.org/10.1186/1479-5868-5-40

Barnett, L. M., Ridgers, N. D., & Salmon, J. (2015). Associations between young children's perceived and actual ball skill competence and physical activty. *Journal of Science and Medicine in Sport*, *18*(2), 167–171. http://doi.org/10.2466/10.25.PMS.120v18x2

Barnett, L. M., van Beurden, E., Morgan, P. J., Brooks, L. O., & Beard, J. R. (2009, March). Childhood motor skill proficiency as a predictor of adolescent physical activity. *The Journal of Adolescent Health : Official Publication of the Society for Adolescent Medicine*. http://doi.org/10.1016/j.jadohealth.2008.07.004

Barnett, L. M., van Beurden, E., Morgan, P. J., Brooks, L. O., & Beard, J. R. (2010). Gender differences in motor skill proficiency from childhood to adolescence: a longitudinal study. *Research Quarterly for Exercise and Sport*, *81*(2), 162–170. http://doi.org/10.5641/027013610X13088554297116

Belton, S., Brien, W. O., Issartel, J., Mcgrane, B., & Powell, D. (2016). Where does the time go? Patterns of physical activity in adolescent youth. *Journal of Science and Medicine in Sport*, 1–5. http://doi.org/10.1016/j.jsams.2016.01.008

Belton, S., Brien, W. O., Wickel, E. E., & Issartel, J. (2013). Patterns of Noncompliance in Adolescent Field-Based Accelerometer Research. *Journal of Physical Activity and Health*, 1181–1185.

Belton, S., O' Brien, W., Meegan, S., Woods, C., & Issartel, J. (2014). Youth-Physical Activity Towards Health: evidence and background to the development of the Y-PATH physical activity intervention for adolescents. *BMC Public Health*, *14*(1), 122. http://doi.org/10.1186/1471-2458-14-122

Burton, A. W., & Miller, D. E. (1998). *Movement skill assessment*. Human Kinetics.

Cain, K. L., Sallis, J. F., Conway, T. L., Dyck, D. Van, & Calhoon, L. (2013). Using Accelerometers in Youth Physical Activity Studies : A Review of Methods. *Journal of Physical Activity and Health*, *10*, 437–450.

Cole, T. J., Bellizzi, M. C., Flegal, K. M., Dietz, W. H., Cole, T. J., Bellizzi, M. C., … Dietz, W. H. (2000). survey and obesity worldwide : international survey, (June 2007). http://doi.org/10.1136/bmj.320.7244.1240

Currie, D., Zanotti, C., Looze, M. De, Roberts, C., & Barnekow, V. (2012). Social determinants of health and well-being among young people.

Esliger, D. W., Copeland, J. L., Barnes, J. D., & Tremblay, M. S. (2005). Standardizing and

Optimizing the Use of Accelerometer Data for Free-Living Physical Activity Monitoring, 366–383.

Evenson, K. R., Catellier, D. J., Gill, K., Ondrak, K. S., Mcmurray, R. G., Evenson, K. R., … Murray, R. G. M. C. (2008). Calibration of two objective measures of physical activity for children. *Journal of Sports Sciences*, *26*(14). http://doi.org/10.1080/02640410802334196

Gallahue, D. L., Ozmun, J. C., & Goodway, J. D. (2012). *Understanding motor development: Infants, children, adolescents, adults. 7th Edition*. (M.-G. Hill, Ed.). Boston.

Griffin, N. S., & Keogh, J. (1982a). *A Model for Movement Confidence. The Development of Movement Control and Co-ordination*. (J. Kelso & J. E. Clark, Eds.). New York: John Wiley.

Griffin, N. S., & Keogh, J. F. (1982b). *A Model for Movement Confidence. The Development of Movement Control and Co-ordination*. (J. A. S. Kelso, Ed.). New York: John Wiley.

Hager, R. L. (2006). Television viewing and physical activity in children. *The Journal of Adolescent Health : Official Publication of the Society for Adolescent Medicine*, *39*(5), 656–61. http://doi.org/10.1016/j.jadohealth.2006.04.020

Hallal, P. C., Andersen, L. B., Bull, F. C., Guthold, R., Haskell, W., Ekelund, U., … Wells, J. C. (2012). Global physical activity levels: Surveillance progress, pitfalls, and prospects. *The Lancet*, *380*(9838), 247–257. http://doi.org/10.1016/S0140-6736(12)60646-1

Hallal, P. C., Victora, C. G., Azevedo, M. R., & Wells, J. C. K. (2006). A Systematic Review This material is the copyright of the original publisher . Unauthorised copying and distribution is prohibited . This material is original publisher ., *36*(12), 1019–1030.

Hardy, L. L., Barnett, L., Espinel, P., & Okely, A. D. (2013). Thirteen-year trends in child and adolescent fundamental movement skills: 1997-2010. *Medicine and Science in Sports and Exercise*, *45*(10), 1965–1970. http://doi.org/10.1249/MSS.0b013e318295a9fc

Harter, S. (1978). Effectance Motivation Reconsidered: Toward a Developmental Model. *Human Development*, *21*, 34–64.

Harter, S., & Pike, R. (1984). The Pictorial Scale of Perceived Competence and Social Acceptance for Young Children The Pictorial Scale of Perceived Competence and Social Acceptance for Young Children, *55*(6), 1969–1982.

Holfelder, B., & Schott, N. (2014). Relationship of fundamental movement skills and physical activity in children and adolescents : A systematic review. *Psychology of Sport & Exercise*, *15*(4), 382–391. http://doi.org/10.1016/j.psychsport.2014.03.005

Lirgg, C. D. (1991). Gender differences in self-confidence in physical activity: A meta-analysis of recent studies. *Journal of Sport & Exercise Psychology*, *8*(1974), 294–310.

Lubans, D. R., Morgan, P. J., Cliff, D. P., Barnett, L. M., & Okely, A. D. (2010). Fundamental movement skills in children and adolescents: review of associated health benefits. *Sports Medicine (Auckland, N.Z.)*, *40*(12), 1019–35. http://doi.org/10.2165/11536850-000000000-00000

McAuley, B. E., & Gill, D. (1983). Reliability and Validity of the Physica SElf-Efficacy Scale in a Competitive Sport Setting. *Journal of Sport & Exercise Psychology*, *5*, 410–418.

McGrane, B., Belton, S., Powell, D., Issartel, J., Mcgrane, B., Belton, S., & Powell, D. (2016). The relationship between fundamental movement skill proficiency and physical self-confidence among adolescents. *Journal of Sports Sciences*, 1–6.

http://doi.org/10.1080/02640414.2016.1235280

McGrane, B., Belton, S., Powell, D., Woods, C. B., & Issartel, J. (2015a). Physical self-confidence levels of adolescents: Scale reliability and validity. *Journal of Science and Medicine in Sport*. http://doi.org/10.1016/j.jsams.2015.07.004

McGrane, B., Belton, S., Powell, D., Woods, C., & Issartel, J. (2015b). Physical self-confidence levels of adolescents: Scale reliability and validity. *Journal of Science and Medicine in Sport*.

Mitchell, B., McLEnnan, S., Latimer, K., Graham, D., Gilmore, J., & Rush, E. (2013). Improvement of fundamental movement skills through support and mentorship of class room teachers. *Obesity Research and Clinical Practice*, *7*, 230–234.

O' Brien, W., Belton, S., & Issartel, J. (2015). Fundamental movement skill proficiency amongst adolescent youth. *Physical Education and Sport Pedagogy*, (April 2015), 1–15. http://doi.org/10.1080/17408989.2015.1017451

O' Brien, W., Issartel, J., & Belton, S. (2013). Evidence for the Efficacy of the Youth-Physical Activity towards Health (Y-PATH) Intervention. *Advances in Physical Education*, *3*(4), 145–153. http://doi.org/10.4236/ape.2013.34024

O'Brien, W., Belton, S., & Issartel, J. (2015). (2015). The relationship between adolescents' physical activity, fundamental movement skills and weight status. *Journal of Sports Sciences*.

O'Neill, J. R., Pfeiffer, K. A., & Williams, H. G. (2008). Motor skill performance and physical activity in preschool children. *Obesity*, *16*, 1421–1426.

Robinson, L. E., Logan, S. W., Webster, E. K., Getchell, N., & Pfeiffer, K. A. (2015). Relationship Between Fundamental Motor Skill Competence and Physical Activity

During Childhood and Adolescence : A Systematic Review Competence and Physical Activity During Childhood and Adolescence : A Systematic Review, (November 2015). http://doi.org/10.1123/kr.2013-0012

Robusto, K. M., & Trost, S. G. (2012). Comparison of three generations of ActiGraph TM activity monitors in children and adolescents. *Journal of Sports Sciences*, *30*(13), 1429–1435. http://doi.org/10.1080/02640414.2012.710761

Sallis, J., Prochaska, J., & Taylor, W. (2000). A review of correlates of physical activity of children and adolescents. *Medicine and Science in …*, (1), 19–21. Retrieved from http://www.researchgate.net/publication/12521182_A_review_of_correlates_of_physical_activity_of_children_and_adolescents/file/9fcfd509495ae32123.pdf

Shavelson, R. J., Hubner, J. J., & Stanton, G. C. (1976). Self-Concept: Validation of Construct Interpretations. *Review of Educational Research*, *46*(3), 407–441. http://doi.org/10.3102/00346543046003407

Slykerman, S., Ridgers, N. D., Stevenson, C., & Barnett, L. M. (2016). Journal of Science and Medicine in Sport How important is young children ' s actual and perceived movement skill competence to their physical activity ? *Journal of Science and Medicine in Sport*, *19*(6), 488–492. http://doi.org/10.1016/j.jsams.2015.07.002

Stodden, D. F., Goodway, J. D., Langendorfer, S. J., Roberton, M. A., Rudisill, M. E., Garcia, C., & Garcia, L. E. (2008). A Developmental Perspective on the Role of Motor Skill Competence in Physical Activity: An Emergent Relationship. *Quest*, *60*(2), 290–306. http://doi.org/10.1080/00336297.2008.10483582

Sutherland, R., Campbell, E., Lubans, D. R., Morgan, P. J., Okely, A. D., Nathan, N., … Wiggers, J. (2016). " Physical Activity 4 Everyone " school-based intervention to prevent decline in adolescent physical activity levels : 12 month (mid-intervention) report on a cluster randomised trial, 488–495. http://doi.org/10.1136/bjsports-2014-094523

Ulrich, D. A. (1985). Test of Gross Motor Development: PRO-ED.

Ulrich, D. A. (2000). *Test of gross motor development 2: Examiner's manual* (2nd ed.). Austin, TX: PRO-ED.

Victoria, D. of E. (1996). *Fundamental motor skills: A manual for classroom teachers*. Melbourne.

Welk, G. J., & Eklund, B. (2005). Validation of the children and youth physical self perceptions profile for young children. *Psychology of Sport and Exercise*, *6*(1), 51–65. http://doi.org/10.1016/j.psychsport.2003.10.006

Woods, C. ., Tannehill, D., Quinlan, A., Moyna, N., & Walsh, J. (2010). *The Children ' s Sport Participation and Physical Activity Study (CSPPA)*. Dublin, Ireland.

World Health Organization. (2010). *Global recommendations on physical activity for health*. Geneva.

Table 1: Adolescent's actual and perceived locomotor, object control and stability competence, Body Mass Index, moderate- to vigorous-intensity physical activity (MVPA) mins/day, and sex differences.

Variable	Range	Mean (SD)	*d*
Perceived Locomotor (0-10)			
All	0 - 10	7.80 (2.81)	0.39
Boys	**0 - 10**	**8.33 (2.82)**	
Girls	**0 - 10**	**7.25 (2.69)**	
Perceived Object Control (0-10)			
All	0 - 10	7.96 (2.66)	0.38
Boys	**0 - 10**	**8.45 (2.73)**	
Girls	**0 - 10**	**7.45 (2.49)**	
Perceived Stability (0-10)			
All	0 - 10	7.67 (2.89)	0.29
Boys	**0 - 10**	**8.08 (2.98)**	
Girls	**0 - 10**	**7.25 (2.73)**	
Actual Locomotor (0-66)			
All	6 - 51	40.45 (5.33)	0.29
Boys	**11 - 51**	**41.22 (4.56)**	
Girls	**6 - 47**	**39.72 (5.90)**	
Actual Object Control (0-48)			
All	6 - 48	41.10 (5.12)	7.19
Boys	**21 - 48**	**42.33 (4.14)**	
Girls	**6 - 48**	**40.00 (5.66)**	
Actual Stability (0-10)			
All	0 - 10	5.65 (3.61)	0.1
Boys	0 - 10	5.74 (3.56)	
Girls	0 - 10	6.08 (3.39)	
Body Mass Index			
All	13.60 - 33.20	20.11 (3.18)	0.29
Boys	**13.60 – 33.20**	**19.66 (3.12)**	
Girls	**14.90 – 33.10**	**20.56 (3.15)**	
MVPA (mins/day)			
All	12.30 – 162.30	50.88 (23.58)	0.51
Boys	**15.40 – 162.30**	**56.09 (25.44)**	
Girls	**12.30 – 124.70**	**46.30 (20.93)**	

Note: Values in bold denote where significant sex differences can be found between boys and girls (p<.01).

Table 2: Multi-level analyses for perceived locomotor, perceived object control, perceived stability, actual locomotor, actual object control, actual stability, and moderate-to-vigorous intensity physical activity (MVPA in mins/day) controlling for Body Mass Index (BMI) and sex.

	β	**SE β**	**LCI**	**UCI**	***p***	***d***
Model 1 outcome: perceived Locomotor						
Actual Locomotor competence	-0.01	0.03	-0.07	0.06	0.81	-0.02
BMI	0.06	0.06	-0.06	0.18	0.32	0.06
Sex	0.92	0.54	-0.15	1.98	0.09	0.10
Model 2 outcome: perceived Object Control						
Actual Object Control competence	0.05	0.03	-0.02	0.12	0.13	0.10
BMI	0.06	0.05	-0.04	0.15	0.26	0.07
Sex	0.60	0.48	-0.34	1.54	0.21	0.07
Model 3 outcome: perceived Stability						
Actual Stability competence	0.07	0.05	-0.03	0.18	0.17	0.08
BMI	0.03	0.05	-0.08	0.13	0.58	0.03
Sex	0.54	0.48	-0.39	1.48	0.26	0.06
Model 4 outcome: MVPA (mins/day)						
Perceived Locomotor competence	0.65	0.48	-0.29	1.59	0.17	0.08
BMI	-0.49	0.49	-1.46	0.48	0.32	-0.06
Sex	**10.37**	**4.02**	**2.50**	**18.24**	**0.01**	**0.15**
Model 5 outcome: MVPA (mins/day)						
Perceived Object Control competence	1.09	0.58	-0.06	2.23	0.06	0.11
BMI	-0.49	0.49	-1.45	0.47	0.32	-0.06
Sex	**10.28**	**3.98**	**2.47**	**18.09**	**0.01**	**0.15**
Model 6 outcome: MVPA (mins/day)						
Perceived Stability competence	0.39	0.53	-0.65	1.43	0.46	0.04
BMI	-0.45	0.50	-1.42	0.52	0.37	-0.05
Sex	**10.72**	**3.97**	**2.94**	**18.49**	**0.01**	**0.16**
Model 7 outcome: MVPA (mins/day)						
Actual Locomotor competence	**0.54**	**0.26**	**0.03**	**1.05**	**0.04**	**0.12**
BMI	-0.26	0.46	-1.15	0.63	0.57	-0.03
Sex	**9.86**	**3.81**	**2.40**	**17.32**	**0.01**	**0.15**
Model 8 outcome: MVPA (mins/day)						
Actual Object Control competence	0.16	0.28	-0.40	0.71	0.58	0.03
BMI	-0.31	0.46	-1.21	0.58	0.49	-0.04
Sex	**10.50**	**3.89**	**2.88**	**18.12**	**0.01**	**0.16**
Model 9 outcome: MVPA (mins/day)						
Actual Stability competence	-0.45	0.51	-1.46	0.55	0.38	-0.05
BMI	-0.39	0.45	-1.26	0.49	0.39	-0.05
Sex	**10.38**	**3.93**	**2.67**	**18.08**	**0.01**	**0.15**

Note: β, beta; SE β, standard error beta; 95% CI, confidence interval; L, lower; U, upper. All models adjusted for the potential of students clustering in schools. Where crude analysis was significant, stratified analysis for each modifier was conducted with the results for each effect modifier shown in Table 3 (e.g. for sex, males and females results are reported). Values in bold denote beta (95% CI), standard error, upper and lower confidence intervals, and significance values.

Table 3: Multi-level analyses controlling for Body Mass Index (BMI), stratified by sex where sex was significant in crude analysis.

	Boys						Girls					
	β	**SE β**	**LCI**	**UCI**	***p***	***d***	**β**	**SE β**	**LCI**	**UCI**	***p***	***d***
Model 4 outcome:												
BMI	**-1.56**	**0.75**	**-3.04**	**0.09**	**0.04**	**-0.17**	0.10	0.10	0.10	0.30	0.32	0.08
Perceived	1.06	0.72	-0.35	2.47	0.14	0.12	0.00	0.02	0.03	0.03	0.84	0.00
Model 5 outcome:												
BMI	**-1.59**	**0.75**	**-3.05**	**0.12**	**0.03**	**-0.17**	0.01	0.01	0.02	0.03	0.45	0.08
Perceived Object	1.48	0.84	-0.17	3.13	0.08	0.14	0.06	0.08	0.10	0.22	0.45	0.06
Model 6 outcome:												
BMI	0.10	0.09	-0.09	0.28	0.30	0.09	0.75	0.59	0.41	1.90	0.20	0.10
Perceived Stability	**0.22**	**0.06**	**0.07**	**0.33**	**0.00**	**0.30**	0.76	0.64	2.02	0.50	0.24	0.10
Model 7 outcome:												
BMI	-1.18	0.73	-2.60	0.25	0.11	-0.13	0.55	0.56	0.55	1.65	0.32	0.08
Actual Locomotor	0.54	0.54	-0.51	1.59	0.32	0.08	**0.55**	**0.28**	**0.01**	**1.09**	**0.05**	**0.16**
Model 8 outcome:												
BMI	-1.24	0.73	-2.67	0.19	0.09	-0.14	0.45	0.57	0.67	1.56	0.43	0.06
Actual Object	-0.30	0.54	-1.35	0.76	0.58	-0.05	0.33	0.31	0.28	0.94	0.29	0.09
Model 9 outcome:												
BMI	0.03	0.11	-0.19	0.24	0.80	0.02	0.43	0.56	-0.66	1.52	0.25	0.06
Actual Stability	**0.46**	**0.20**	**0.06**	**0.86**	**0.02**	**0.19**	-0.70	0.62	-1.91	0.5	0.25	-

Note. β, beta; SE β, standard error beta; 95% CI, confidence interval; L, lower; U, upper. All models adjusted for the potential of students clustering in schools. Values in bold denote where significance lies.