Predictive Strength of Physical Education -centered Physical Literacy Indicators on Physical Activity

Abstract

The aim of this study was examine the predictive strength of selected physical education -centered physical literacy indicators on elementary school students' accelerometer measured moderate-to-vigorous intensity physical activity (PA) (MVPA). This study was a cross-sectional study with a sample of 450 fifth grade children (M = 11.26[.32]; $n_{females}$ = 194; n_{males} = 256). A set of predictor variables (motor competence, in-class physical education [PE] PA, health-related fitness, and PE motivation and enjoyment) and MVPA as a single outcome variable were collected. The entire model explained almost 30% of the MVPA (R^2_{adj} = .298). Cardiovascular endurance (β = .42, p < .001, CI95% [.22, .62]) and MVPA in PE (β = .27, p = .004, CI 95% [.09, .44]) were statistically significant predictors of total MVPA. It can be concluded that of all included variables, cardiovascular endurance and MVPA in PE were the most important factors contributing to healthy levels of MVPA in childhood.

***Keywords*:** accelerometry, physical education, moderate to vigorous intensity

The goal of school physical education (PE) is to educate physically literate individuals and enhance overall student development (Society for Health and Physical Educators, 2013) Association for ASPE). Physical literacy can be defined as "*the motivation, confidence, physical competence, knowledge, and understanding to maintain physical activity (PA) throughout the life course*" (Whitehead, 2010) or "*the ability, confidence, and desire to be physically active for life*" (The Aspen Institute, 2015). Despite the slight differences in the definitions, the term physical literacy can be understood as an individual's capacity to engage in a physically active lifestyle (Longmuir & Tremblay, 2016). Due to prolonged obesity epidemic (Hurt, Kulisek, Buchanan, & McClave, 2010), it has been advocated that the primary focus of school PE programs should be in helping students to meet the daily 60 minutes of moderate-to-vigorous intensity physical activity (MVPA) recommendation (US Department of Health and Human Services, 2018). Although mandatory PE with the standardized curriculum (i.e., a scripted curriculum with clear objectives and assessments) has been found to be the most impactful school-based policy to increase PA in youth (Bassett et al., 2013), very little is known which PE-centered physical literacy components are the most beneficial in regards to healthy PA behavior in childhood (Corbin, 2016). Thus, the aim of this study was to examine the predictive strength of selected PE-centered physical literacy indicators on elementary school students' objectively measured MVPA.

Stemming from the physical literacy definitions (The Aspen Institute, 2015; Whitehead, 2010) and Nationals PE Standards (Society for Health and Physical Educators, 2013), physically literate individual should be able to a) be competent in motor skills, b) engage in a healthy dose of PA, c) demonstrate health-enhancing levels of fitness, and d) to be motivated toward and enjoy regular PA participation. Although the National PE Standards highlight the balanced

approach of students' meeting psychomotor, cognitive, and affective learning outcomes (Society for Health and Physical Educators, 2013), from the public health perspective, achieving daily 60 minutes of MVPA is a worthy goal because regular MVPA has shown to have numerous benefits for short- and long-term health of PE students, e.g., improved bone health, healthy body composition, reduced symptoms of depression, and decreased likelihood of developing and type 2 diabetes mellitus (US Department of Health and Human Services, 2018). Although it is well known that PA behavior is influenced by a complex interaction of demographic, (e.g., gender [boys more active] and age [-]); anthropometric (body mass index [BMI; -]); socio-psychological (e.g., intrinsic motivation/competence/self-efficacy [+]); and behavioral (e.g., previous PA [+]) determinants (Sallis, Prochaska, & Taylor, 2000; Seabra et al., 2013), only some of these determinants can be intervened in school PE. Thus, to examine the contribution of PE-centered physical literacy on MVPA (see Table 1 for operationalized definitions and Figure 1 for conceptual framework), the determinants of motor competence, MVPA in PE, health-related fitness, and PE motivation and enjoyment were selected based on the previous research evidence that has shown the variables to be directly linked to MVPA (Barnett, van Beurden, Morgan, Brooks, & Beard, 2009; Bassett et al., 2013; Chen, Hammond-Bennett, Hypnar, & Mason, 2018; Dishman, Saunders, Felton, Ward, & Pate, 2005; Owen, Astell-Burt, & Lonsdale, 2013).

To date, research has demonstrated that motor competence (sometimes used terms include e.g. motor coordination, fundamental movement skills, or motor skill proficiency) is related to PA engagement from childhood to adolescence and from adolescence to young adulthood (Barnett et al., 2009; Jaakkola et al., 2016). It has shown that children with proficient motor competence (i.e., object control skills) have a 20% higher probability of to engage in vigorous intensity PA in adolescence compared to the children with a lack of appropriate object

control skills. Additionally, is has been found that that childhood object control skills accounted for 3.6% of participation in MVPA, and 18.2% of participation in organized PA in adolescence (Barnett et al., 2009). In addition, a longer-term relationship between boys' motor competence and PA has establish, research showing that PA and motor competence in early adolescence explains 29% of total PA in late adolescence (Jaakkola & Washington, 2013).

Student ~~participation~~ in-class PA participation is one of the key objectives of PE, and it is an important PE outcome contributing to healthy daily levels of PA (Bassett et al., 2013; US Department of Health and Human Services, 2018). Specifically, research has shown that students who participate in daily PE are more likely to achieve recommended 60 minutes of daily MVPA (US Department of Health and Human Services, 2018). When examining the school time MVPA, mandatory PE has been found to be one of the most effective means to increase total daily MVPA (Bassett et al., 2013). The comprehensive large-scale study by Bassett et al. (2013) has shown that daily mandatory PE will contribute 23 minutes toward elementary school students total MVPA and additional six minutes will be gained if the schools use standardized PE curriculum compared to traditional PE.

Health-related physical fitness and regular PA are reciprocally associated and enhance one another (Stodden et al., 2008). Previous research has shown that health-related fitness components can explain 10% to 13% of total PA among children (Chen et al., 2018), with cardiovascular endurance being strongest predictor, followed by upper body strength and endurance (Chen et al., 2018). It has been shown that cardiovascular fitness in late adolescence has a long-term predictive strength predicting 31% and 24% of PA in men and women, respectively (Glenmark, Hedberg, & Jansson, 1994). On the other hand, research has shown

muscular strength and endurance and flexibility to have more positive effect on skeletal health compared to cardiovascular endurance (Blair, Cheng, & Holder, 2001).

A plethora of studies has shown PE motivation and enjoyment to be determinants of PA. This study operationalized motivation using self-determination theory (Deci & Ryan, 1985), and the operationalization of the motivation concept is presented in Table 1. Research has shown adaptive motivation (i.e., intrinsic motivation and the most intrinsic forms of extrinsic regulation) in PE to be a predictor of school students' total MVPA, with the predictive strength of adaptive motivation in PE on total MVPA ranging from 8% to 12% (Owen et al., 2013; Yli-Piipari, 2011). In addition, adaptive motivation has shown positively associate with PA intensity in PE (Owen et al., 2013), decisions to enroll in PE as an optional subject (Ntoumanis, 2005), and PA during leisure-time (Chatzisarantis & Hagger, 2009). PE enjoyment, on the other hand, has shown to be positive predictor of total MVPA (Dishman et al., 2005) and leisure-time MVPA (Dishman et al., 2005; Sallis et al., 2000) in adolescence. The predictive strength of PE enjoyment on in-class MVPA has found to be moderate 31% (Gao, 2008), whereas predictive power on total MVPA has found to be weak (Dishman et al., 2005).

Several variables (e.g., BMI, gender, accelerometer wear time, and classroom membership) have shown to moderate MVPA (Deng & Fredriksen, 2018). The relationship between BMI and total MVPA is reciprocal, BMI affecting the engagement in PA and vice versa (Deng & Fredriksen, 2018). It has been shown that students with higher BMI accumulate less MVPA during PE lesson (Gao, Oh, & Sheng, 2011). In addition, it has been shown that overweight school students are less likely to enroll in PE when offered a selective course (Ntoumanis, 2005). In addition, PA research has shown that accelerometer wear time may be one factor that confounds accelerometer based studies (Choi, Liu, Matthews, & Buchowski, 2011).

Research has shown that physically inactive study participants are less interested to use wearable PA tracking devices, which can impact the wear-compliance (Alley et al., 2016). Finally, it is well regarded phenomenon that school-based studies are sensitive to the biases that are due hierarchical dependence of the data. In other words, students are members of their schools and classrooms, and that may affect their PA during and after school day (Raudenbush & Bryk, 1986). Although this data dependence has been found to be relatively small in Finnish PE context (Yli-Piipari, 2011), it has been recommended to be accounted in the school-based studies (Raudenbush & Bryk, 1986).

Despite the previous studies that have shown that children's total PA activity is impacted by numerous variables, there is a need to increase common knowledge base of the potential effect of physical literacy components on total MVPA in childhood (Corbin, 2016). In this study, the physical literacy indicators of motor competence, MVPA in PE, health-related fitness, and PE motivation and enjoyment were selected, because these indicators have shown to be impacted by quality school PE instruction (Bassett et al., 2013; Gao, 2008; Jaakkola et al., 2016; Owen et a., 2013; Society for Health and Physical Educators, 2013). Therefore, the purpose of this study was to examine the predictive strength of these selected physical literacy indicators on elementary school students' objectively measured MVPA. It was hypothesized that after controlling gender, age, accelerometer wear time, and the nested structure of the data, MVPA in PE, adaptive motivation, and enjoyment, will have a weak-to-modest predictive strength on total MVPA. In addition, it was hypothesized that motor competence and health-related fitness components will be predictors of total MVPA, and this effect will be moderate in size.

Method

Study Design and Participants

This study was a cross-sectional study with the data collected during one collection point in between late August to early October in 2017 in 35 schools across Finland. The sample is nationally representative in terms of geographical representation, a number of schools, and a number of students. A sample of 450 5th grade children ranging from 10 to 12 years of age (M = 11.26[.32]; $n_{females}$ = 194; n_{males} = 256) participated in the study. Participant assents, parental consents, and university's institutional review board, i.e. ethical committee acceptance were collected prior to the study.

In Finland, 5th grade students have 90 minutes of weekly mandatory PE, normally offered in two 45 minutes classes. The mission, objectives, and content of Finland's PE are similar to the US, with the exception that - oftentimes - in Finland 5th grade PE is taught by a classroom teacher, whereas in the US, PE is taught by a trained PE specialist.

Procedures

Cross-sectional data were collected in three meetings, each conducted within three days. First, motor competence and physical fitness data were collected in school gym during PE classes. Second, data on students' PE motivation and enjoyment were gathered in a school classroom setting. After collecting the questionnaires, accelerometers were provided to students. A letter explaining the appropriate use of accelerometers, devices were given to the participants and their parents. Additionally, teachers were informed to check every morning that the students wore accelerometers as planned. Finally, weight and height of each participant were measured in a quiet and private dressing room by researchers (trained graduate students under the supervision of the professor leading the study).

Measurements

Criterion Variable. ***Total MVPA.*** MVPA was measured by Actigraph WGT3X+ accelerometers. The participants wore an accelerometer on their right hip during waking hours for seven consecutive days excluding the time when engaged in aquatic activities. A raw acceleration frequency of 30Hz was used, and data were converted into 15s epoch counts. A customized Visual Basic Macro for Microsoft Excel software was used for data reduction. A valid day of PA monitoring included the measured values ≥ 500 min/day for at least two weekdays and one weekend day. Values over 20,000 counts per minute (cpm) were ruled out as spurious accelerations (Heil, Brage, & Rothney, 2012). Evenson cut-points were used to calculate MVPA (≥2296 cpm) (Evenson, Catellier, Gill, Ondrak, & McMurray, 2008).

Predictor Variables. ***Motor competence***. Motor competence measures included the following tests: throwing-and-catching combination (Jaakkola, et al., in press), two-leg jump, balance beam (Iivonen, Sääkslahti, & Laukkanen, 2015), and five-jump (Nupponen, Soini, & Telama, 1999) tests.

Throwing-catching combination test. This test measured fundamental motor skills of throwing and catching. In the test, a participant had 20 attempts to throw a tennis ball to a 1.5m x 1.5m sized target area (90cm above the floor) and catch the ball after one bounce. Throwing distances for the girls and the boys were seven and eight meters, respectively. The final score of the test is the number of correctly performed throwing-catching combinations. The throwing-catching combination -test is widely used instrument in Finnish PE studies (e.g. Jaakkola et al., submitted), and the test has shown acceptable reliability and validity in children (Jaakkola, Sääkslahti, Liukkonen, & Iivonen, 2012).

Two-leg jump test. The two-leg jump test measured participants' agility and dynamic balance. In the test, participants jumped feet in a parallel position from side to side over a small

wooden beam (60 × 4 × 2 cm) as many times as possible during a 15s. The test was conducted twice, and the final score was the sum of two attempts. With acceptable reliability and validity in this age group, the two-leg jump test is widely used instrument in studies related to children's motor coordination (Jaakkola et al., 2012; Iivonen, Sääkslahti, & Laukkanen, 2015).

Balance beam test. The balance beam test was used to measure participants' dynamic balance. In the test, a participant was asked to walk backwards on three meter long balance beams of decreasing width (6, 4.5, and 3 cm). After one practice walk, a participant was asked to walk backward each beam three times. Every step a participant was able to perform on the beam were counted. The maximum amount of steps on each walk was eight. The final score was the sum of steps a participant was able to perform in nine attempts (maximum score 9 x 8 = 72). The balance beam test has shown to be a reliable and valid test for children (Iivonen, Sääkslahti, & Laukkanen, 2015; Jaakkola et al., 2012).

Five-Jump Test. The five-jump test was used to measured participants' lower limp explosive power. In the test a participant jumps five times beginning and finishing feet in a parallel position. The score of the test is the length (cm) of five jumps from the starting line to the landing spot. A five-jump test has widely been used in Finnish PE studies and its reliability and validity has reported to be acceptable in school-aged children (Jaakkola et al., 2012, in press).

Health-related physical fitness. Health-related physical fitness was measured by the 20 meter Progressive Aerobic Cardiovascular Endurance Run (PACER) (Plowman & Meredith, 2013), push-up test and sit-up tests procedures identical with the tests of the FitnessGram (Plowman & Meredith, 2013).

PACER. The PACER was used to measure participants' cardiorespiratory endurance. Adhering to the cadence with an increasing pace, participant's goal was to run as many 20m laps as possible. The PACER test has shown to be reliable and valid test to measure cardiovascular endurance in different cultures (Olds, Tomkinson, Léger, & Cazorla, 2006).

Push-up test. The test was used to measure participants' upper body muscular endurance and strength. The boys and the girls conducted different versions of the test, in which boys did the regular push-ups and girls modified push-ups (knees on the floor) with cadence. Participants started push-up with elbows in 90-degree angle. The final score of the push-up test is the number of correctly completed push-ups (max. 60 repetitions*).* The push-up tests have been found to be valid measures to measures upper body muscular endurance and strength (Jaakkola et al., 2012).

Abdominal muscles endurance test. The abdominal test was used to measure participants' abdominal muscles muscular endurance and strength. In a starting position, participants laid on their backs with knees bent at 120 degrees, both feet are on floor, and arms are straight and parallel to the trunk. Measuring tape is situated under participant's legs so that their fingertips are just resting on the nearest edge of tape. In the test a participant is curling up so that their fingers slide across the measuring tape until fingertips reach the other side of tape. The final score is the number of correctly completed curl-ups reached before participant is unable to keep on pace are counted. The rhythm for the performance was coming from the cadence. This abdominal test has found to be reliable and valid test for abdominal strength and endurance (Jaakkola et al., 2012).

PA in PE. MVPA in PE was measured using accelerometers following the guidelines above. Data were recorded using the actual time spent in PE.

PE motivation. PE motivation was measured using the Finnish version of the Revised Perceived Locus of Causality Scale (PLOC-R; Vlachopoulos, Katartzi, Kontou & Goudas,

2011). The PLOC-R includes the item stem: "I take part in PE…", and comprises 19 items which analyze intrinsic motivation (4 items; e.g., "Because I enjoy learning new skills"), identified regulation (4 items; e.g., "Because it is important to me to improve in the drills we do in PE"), introjected regulation (4 items; e.g., "Because it would bother me if I didn't"), external regulation (3 items; e.g., "So that the teacher won't yell at me"), and amotivation (4 items; e.g., "But I really feel I'm wasting my time in PE"). All items are rated on a 5-point Likert scale ranging from 1 = strongly disagree to 5 = strongly agree. Internal consistency values for this scale were acceptable .78 (intrinsic motivation), .82 (identified regulation), .76 (introjected regulation), .74 (extrinsic regulation) and .89 (amotivation). The scale has been shown to reliable and valid test to measure PE motivation (Vlachopoulos et al., 2011).

Enjoyment in PE. Enjoyment in PE was measured by the Finnish version of the Enjoyment subscale from the Sport Commitment Questionnaire -2 (SCQ; Scanlan & Simmons, 1992). The scale consists of five items (e.g., "I enjoy PE lessons") which are rated on a 5-point Likert scale ranging from 1 = strongly disagree to 5 = strongly agree. The SCQ has the item stem of "In my PE classes…". The Finnish version of the enjoyment scale has been found to be a valid and reliable tool when used with students during PE classes (Kalaja, Jaakkola, Liukkonen, & Watt, 2010). In this study, Cronbach analysis showed an acceptable internal consistency (Cronbach's $\alpha = .91$).

Controlling Variables. ***BMI and gender***. The continuous variable examined was BMI and the dichotomous variable was gender (male or female). Student height and weight were measured by the researches, and BMI was calculated by researches using a formula of the BMI = mass/height^2.

Accelerometer wear time. To control the accelerometer wear time in the analyses, wear time was included in the analyses. Specifically, periods of 30 minutes of consecutive zero counts were defined as non-wearing time.

Classroom membership. To control the potential nested structure of the data, classroom membership was included in the analyses.

Statistical Analyses

Normality of the data (outliers, kurtosis, and skewness) and descriptive statistics (aggregated mean and standard deviation [SD]) were assessed. Second, hierarchical multiple regression analysis was conducted to test the predictive strength of the predictor variables (motor competence, PA in PE, health-related fitness, PE motivation, and PE enjoyment) on participants' total MVPA. BMI, gender, accelerometer wear time, and classroom membership were set as controlling variables. Independent dimensions of health-related fitness and PE motivation were included in the analyses, due to considerable differences in the predictive strength between variables (Jaakkola et al., 2016). Forming a standardized composite score would potentially dilute the individual effects of the predictor variables, and thus potentially mask the existing relationships. IBM SPSS Statistics for Windows, Version 22 (2017 SPSS Inc.; IBM Corp.; Armonk, NY) was used for the analyses.

Results

Descriptive statistics are presented in Table 2. A test carried out to evaluate the normality of the distribution of the variables in the research variables revealed the variables to be within the limits of -2 to +2 for skewness and kurtosis. The entire data included 3.9% of missing value data points, as 62 students did not provide balance beam test scores and 46 students missed MVPA in

PE measurements. The missing completely at random test ($\chi^2 = 344.27$, $df = 320$, $p = .168$) showed that data with and without missing information were similar, and therefore missing values were expected to be missing completely at random.

Table 3 shows the main findings of the study. The explanatory power of the controlling variables (BMI, gender, accelerometer wear time, and classroom membership) was not statistically significant on participants' MVPA ($R^2_{adj} = .114$). However, the entire model comprising of controlling and criterion variables explained almost 30% of the MVPA ($R^2_{adj} = .298$). The results showed that cardiovascular endurance ($\beta = .42$, $p < .001$, CI95% [.22, .62]) and MVPA in PE ($\beta = .27$, $p = .004$, CI95% [.09, .44]) were statistically significant predictors of total MVPA. The findings did not show statistically significant predictive power on any of the PE motivation variables, PE enjoyment, motor competence, or muscle strength and endurance variables, but gender ($MVPA_{boys} > MVPA_{grils}$) and wear time (the physically active participants had better compliance) had a statistically significant relationship to MVPA.

Discussion

The purpose of this study was to examine the predictive strength of selected PE-related physical literacy factors, e.g. motor competence, MVPA in PE, health-related fitness, and PE motivation and enjoyment on elementary school students' objectively measured MVPA. The review of literature demonstrates that very little is known which of these PE-centered physical literacy components are the most beneficial for total MVPA in late childhood.

The results of this study showed that the PE-centered physical literacy model explained almost 30% of students' total MVPA, whereas the predictive strength of PE-related physical literacy factors was 19%. This finding indicates that the selected school PE health literacy factors

have a role in children's PA, but numerous other demographic, socioeconomic, socio-psychological, and behavioral factors beyond PE influence school students' PA behaviors (Sallis et al., 2000; Seabra et al., 2013). The findings partly supported our hypotheses showing that of all selected factors, cardiovascular endurance was the strongest predictor of total MVPA. These findings corroborate the previous findings (Jaakkola et al., 2016), which have showed that, in the Finnish context, health-related fitness (including cardiovascular endurance, muscle strength, and muscle endurance) predicted self-reported MVPA six years later. School PE has a great potential to improve school students' cardiovascular endurance but, unfortunately, due to a lack of weekly instructional time this potential is not usually materialized. Knowing that the students in our sample had only 90 minutes of PE weekly, it is likely that cardiovascular endurance of these students was mainly developed through out-of-school physical activities and sport participation. Nevertheless, school PE is a very important context to teach students how to develop their cardiorespiratory endurance (Committee on Physical Activity and Physical Education in the School Environment, 2013).

Supporting our study hypotheses, another significant predictor variable was students' engagement in MVPA in PE classes. This finding suggests that, even with a minimal PE instruction time (in this study the instruction time was 90 minutes), PE is an important context contributing to the total MVPA among elementary school students. This study corroborates the findings of the previous studies showing school PE to be the most effective strategy to increase school-day PA (Bassett et al., 2013). This study showed that, on average, these study participants engaged in little over 20 minutes of MVPA during PE. Although contributing only one third of the recommended daily 60 minutes of MVPA, this amount was enough to be a significant predictor of elementary students' total MVPA profile. Altogether, these findings suggest that

elementary schools should provide PE more frequently to maximize students' time spent in MVPA and subsequently improve their cardiovascular endurance.

The study showed that other PE-centered components of physical literacy - muscular strength and endurance, motor competence, PE motivation, or PE enjoyment - did not have a significant relationship with total MVPA. It is interesting that none of the motor competence variables, such as throw and catching skill, agility, balance, or lower limp power, were related to total MVPA in our sample of upper elementary school students. This finding contradicts with our hypothesis and the studies that have shown children with proficient motor competence have a greater likelyhood to engage in PA (Barnett et al., 2009; Jaakkola et al., 2016). Specifically, it has been shown previously that childhood object control skills account for 3.6% of participation in MVPA and 18.2% of participation in organized PA in adolescence (Barnett et al., 2009). Similarly, these findings do not support the theorization of Stodden (2008), which have argued that both cardiovascular endurance and motor competence are determinants of PA. However, the non-significant relationship between abdomen / muscle strength endurance and MVPA was not unexpected, because of all health-related fitness components, cardiovascular endurance has shown to have the strongest relationship with total MVPA (Blair, Cheng, & Holder, 2001; Chen et al., 2018). In addition, previous research has shown that muscle strength and endurance have a stronger relationship with skeletal health (Blair, Cheng, & Holder, 2001).

It was also unexpected that motivation and enjoyment in PE did not associate with total MVPA engagement. Although the cross-sectional relationship between PE motivation and enjoyment and total MVPA have been often established, the longitudinal relationship between these constructs has been moderate at best (Yli-Piipari et al., 2011). In addition, numerous barriers, e.g. time constraints, longer school days, more homework, have shown to diminish the

predictive effect of PE motivation on PA behavior (Yli-Piipari et al., 2018). Relying on the previous studies in self-determination and enjoyment in PE, we do, however, argue that school PE has an important role in increasing self-determined motivation and enjoyment toward PA (e.g., Chatzisarantis & Hagger, 2009). Although the children of this study enjoyed and were highly motivated toward PE, this did not relate to total MVPA. Sometimes, young children has limited possibilities to participate in physically active play after school hours, despite their motivation to be physically active. Research has shown that, over time, children's PA behavior has transferred from free physically active outside play to parent-assisted and -supported sports (Tremblay et al., 2016). These positive socio-cognitive and affective experiences, however, are important when children and adolescents are old enough to make their own decisions whether they are physically active or not (Hagger et al., 2016).

This study has several strengths. First, this study aimed to shed a light on school PE-based physical literacy factors that are important contributors in total MVPA. Second, this study used accelerometers to track participants' PA across a large sample size. However, this study also had some limitations. Firstly, a cross-sectional design does not allow us to draw conclusions on the cause and effect between independent and criterion variables. Secondly, this study utilized only product-oriented (i.e., focusing on the end result) instead of process-oriented (i.e., focusing on the factors other than end result, such as technique) measures to analyze students' motor competence. It may be that measuring the technique of e.g. throwing/catching (process-oriented measure) rather than number of catches (product-oriented) may be more sensitive measure to collect data on 11-year-old students' motor competence (Donnelly, Mueller, & Gallahue, 2017).

Conclusions and Practical Implications

It can be concluded that of all variables included in the study, cardiovascular endurance and MVPA during scheduled PE classes were the most important PE-related physical literacy factors contributing to a healthy levels of MVPA in childhood. These findings advance the previous work of Whitehead (2010) which has recognized the importance numerous physical literacy factors. This study has practical implications to PE practitioners and researchers alike. Although school PE has multiple objectives, PE teachers should include cardiovascular improving exercises in the curriculum to positively impact students' total PA. Future studies should investigate the association of broad range of physical literacy variables and PA engagement in longitudinal design across the samples of school students of different ages.

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