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REVIEW ARTICLE

Physical Literacy, Physical Activity and Health: Toward an Evidence-Informed Conceptual Model

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Abstract

Physical literacy (PL) provides a powerful lens for examining movement in relation to physical activity (PA) and motor skill outcomes, environmental context, and broader social and affective learning processes. To date, limited consideration has been given to the role PL plays in promoting positive health behaviours. There is no clear conceptual framework based on existing empirical evidence that links PL to health, nor has an evidence-informed case been made for such a position. The purpose of this paper is to (1) present a conceptual model positioning PL as a health determinant, and (2) present evidence in support of PL as a health determinant, drawing on research largely from outside physical education. Viewing PL from the perspective of a multidimensional, experiential convergence process enables it to be differentiated from other models. However, parallels between our model and existing models that focus on movement competence are also drawn. Arguing from a pragmatic perspective on PL, we present evidence for positioning PL as a determinant of health from two literature sources: research on motor coordination disorders in children, and associations between motor competence, PA and health in typically developing children. Statistical modelling approaches consistent with the concept of PL are discussed. Results from these approaches—confirmatory factor analysis and cluster analysis—support the idea that measures related to motor competence, motivation and positive affect work in an integrative manner to produce differences in PA and subsequent health outcomes in children. There is increasing interest in PL, particularly in the field of public health. Presenting a model that explicitly links PL to health can lead to the generation of new research questions and the possibility of broadening impact beyond the context of physical education alone. To date, there has been little conceptual attention to what positioning PL as a determinant of health means. By providing an evidence-based model of PL as a determinant of health, we hope to further the discussion and stimulate increased empirical research in the field.

Key Points

Physical literacy (PL) has been defined as the competence, confidence and knowledge to be physically active for life. We provide an expanded definition and then present a conceptual model positioning PL as a health and disease determinant, based on evidence drawn largely from work outside physical education.

Evidence from research on motor coordination disorders in children, and from associations between motor competence, physical activity and health in typically developing children, support the positioning of PL as a determinant of health and disease.

By providing conceptual direction concerning what positioning PL as a determinant of health and disease means, and outlining an evidence-based model of PL as a determinant of health, further discussion and empirical research may be conducted in the field.

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1 Background

Physical literacy (PL) is a multidimensional concept [1] which has agreement with scholars on at least some of its definition components. For example, virtually all definitions include competence in movement skills as a core domain [2, 3]. Importantly, these movement competencies are applied across a range of contexts, including land, air and water [4, 5]. Positive affect, expressed in terms of fun and enjoyment, is also present [6], and motivational constructs such as confidence and self-competence are also central to the concept [3, 7, 8]. Finally, definitions include understanding movement as an essential condition of human experience—sometimes described as an embodied experience [5]. Also, the social aspects of movement are an implicit imperative of PL [9]. From this perspective, PL should be considered a concept that captures broader social processes that contribute to lifelong learning [2]. Given the inclusion of physical, cognitive, social and affective domains within these definitions, when holistically conceived, PL provides a potentially powerful lens for examining movement in relation to physical activity (PA) and motor skill outcomes, and broader social, cognitive and affective processes. No doubt this accounts for its popularity across a diverse range of practitioners and is one reason it has been gaining traction among the research community.

Given that physical competence, positive affect, motivational constructs and the embodied experience have been identified before across a diverse range of literatures, the concept of PL inevitably evokes the question of novelty (e.g. Lounsbery and McKenzie [10]). Specifically, is PL just an amalgam of previously established constructs, or is indeed the whole greater than the sum of the individual parts? Of course, this is not an easy question to answer, but interest in the concept, as evidenced by the proliferation of published papers over the past few years, seems to suggest there is a belief that there is something to the totality of the concept that brings value beyond its constituent components. Likewise, we contend that PL actually presents as a new concept worthy of inquiry rather than simply a rehashed theory.

There is a 'tradition' within the field of physical education that PL is an embodiment of human experience, and the notion that it be used as a means for rationalizing other pursuits is therefore downplayed [1, 4, 11]. According to this perspective, the PL journey is inherently part of our identity/experience, and therefore has value in its own right. At the same time, other traditions see PL as a means to achieve other ends, such as increasing PA and/or increasing participation [6, 12]. These need not be mutually exclusive perspectives, but the former tradition has dominated the discourse in academic writing, and a full consideration of the role that PL plays in promoting more broadly positive health behaviours has received far less attention.

It is becoming clear that if PL is in reality a gateway to increasing PA [13, 14], then it follows that PL must also be a necessary determinant of health via its impact on PA. At present, there is no clear conceptual framework based on existing empirical evidence that links PL to health, nor has an evidence-informed case been made for such a position. In this paper, we attempt to address both points. First, we present a conceptual model positioning PL as a health (and disease) determinant, based on how professional communities (e.g. public health) might think about PL in the context of health promotion and disease prevention. Next, we present evidence in support of PL as a health determinant. While we lack direct empirical connectivity between PL and health outcomes at this time, we feel there is sufficient evidence to warrant further research into this relationship.

Following Edwards and colleagues [3], we feel it is important to declare a philosophical position on PL. Unlike an idealist perspective, which eschews the notion of separating and/or measuring the components identified in the concept of PL, we take a pragmatic approach in this paper, arguing that PL can be measured, and provide support for our argument by drawing mostly on quantitative studies and statistical approaches to the problem.

2 A Conceptual Model

2.1 Beginning with a Holistic Conceptualization of Physical Literacy

Figure 1 shows a model positioning PL as a primary determinant of health and disease, via a fully mediated model involving PA, the positive physiological adaptations that result from acute and chronic exposures to PA, and the potential moderating (interactive) effects of both individual level and social/environmental conditions on the process. For simplicity, we have depicted PL as a reciprocal, intertwining concept of motor, social, affect and motivational factors consistent with its accepted definitions [3, 9, 13, 15]. Importantly, the cyclical nature of the associations among its constituents emphasises the positive cycling engagement that links physical/motor competence to its affective and behavioural/motivational elements. Knowledge is placed outside the loop, emphasizing that knowledge arises as an outcome of the process of the cycle of engagement but can influence positive engagement as well (depicted graphically by the arrows shown in both directions). To our minds, this depiction emphasises the importance of considering the dynamic inter-relationships among these concepts, which differs from a more 'additive' consideration of these components. The inter-dependencies of these factors reinforce the consideration of PL as a holistic concept. By this we mean that PL is presented as an engagement cycle wherein the

relationships among motor competence, social, affective and motivational processes, and knowledge are viewed as reciprocal and reinforcing. For example, successfully learning a new skill can lead to a sense of competence, which increases confidence to participate with others, which in turn produces positive feeling states such as enjoyment and a sense of fun. As this is fundamentally a learning cycle, we can think of what emerges from this cycle of engagement as embodied knowledge, which itself encourages further participation. Although we separate and divide these concepts for heuristic purposes, they are experienced inter-dependently and holistically.

This holistic framing is what we consider to be the most powerful aspect of the concept of PL. Critically, it should not be exclusive to motor skills (which at times has been the case); rather, it also encompasses an individual's competence and confidence to engage in a variety of activities, in a variety of environments, and emphasizes that one can extract positive experiences from movement and learn to value the experience of embodiment [6]. While existing models and concepts include some of these domains as predictors of PA (e.g. Stodden et al. [16] and Hulteen et al. [17]), PL emphasises the convergence of these elements. Consistent with the cycle of engagement we have already identified, we call this a *multidimensional, experiential convergence* of motor, affect, social and cognitive components. We argue that execution of motor performance on its own is insufficient for learning if it is not experientially linked with positive emotional states (enjoyment), which leads to a desire to repeat the skill and use it to engage in other activities such as sport (motivation), all within a particular social context or physical environment. While we may separate these elements for empirical consideration, they are experienced holistically and without, necessarily, conscious reflection. In other words, this multidimensional, experiential converging needs to be conceptualised as one of process (interactive), rather than reducing it to its constituent components that together describe an experience. While it is often presumed that this convergence exists in order for motor learning to be successful (i.e. Stodden et al. [16]), it is less often explicitly

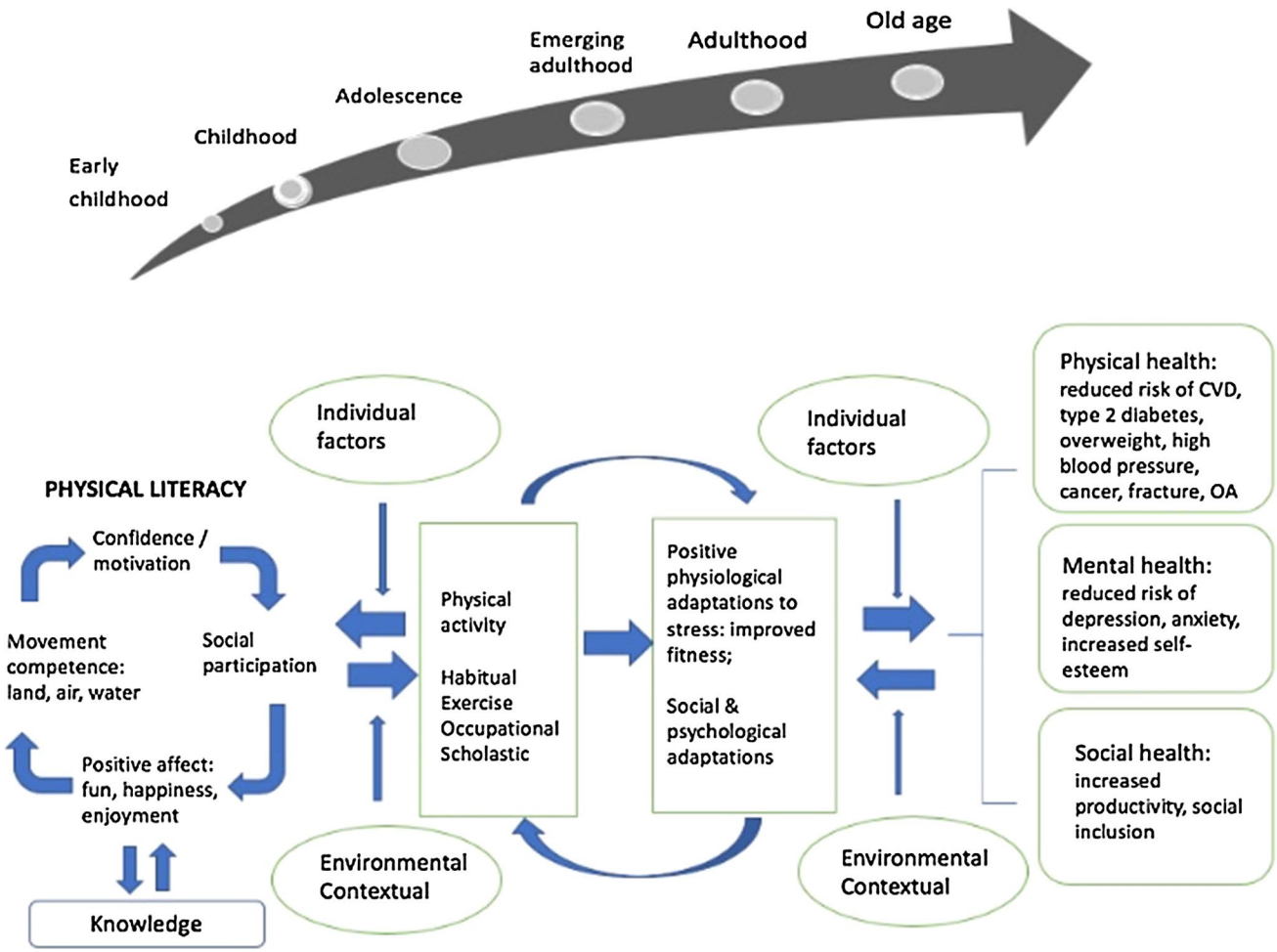

Fig. 1 Conceptual model linking physical literacy, physical activity and health. *CVD* cardiovascular disease, *OA* osteoarthritis

identified in conceptual models in this way. We have also used opposing arrows connecting PL to PA in Fig. 1, emphasising the important reciprocal developmental relationships between both. Hence, PL is important for sustained participation in PA, but development of PL also occurs through both unstructured (i.e. free play, recreational pursuits) and structured PA (e.g. sport, physical education). Indeed, there is evidence to show that a higher frequency of participation in sport increases active free play [18], suggesting the possibility that skills learned in sport may promote greater participation in active free play.

2.2 Physiological, Psychological and Social Responses to Physical Activity

The boxes (see Fig. 1) at the core of the model—PA and adaptive stress responses—are widely recognised in the exercise physiology, PA and health literature. Simply put, PA can lead to a variety of positive physiological adaptions that arise in response to stress. These adaptations, in turn, confer positive health benefits [19]. Improved strength and cardiorespiratory fitness, and the release of neurotransmitters such as serotonin in the brain, are but a few examples of such responses [20, 21]. It should be noted that we have hypothesised reciprocal relationships between PA and these adaptations: strength and improved fitness, for example, are not only products of PA (exercise) but also will positively influence future PA participation [16]. That these positive stress adaptations then lead to positive health outcomes, such as lower blood pressure, reduced risk of all-cancer mortality and regulation of blood sugar, is also widely documented [22]. What is new in this model is the positioning of PL as a determinant of PA behaviours within this more conventional and widely accepted part of the model. For example, the use of PL as a holistic concept including affective, motivation, social and knowledge domains together differentiates our model from others, where, for example, one might include fundamental movement skills (alongside other factors such as competence) alone as a predictor of the chain of effects flowing from PA (i.e. Stodden et al. [16] and Hulteen et al. [17]).

2.3 Individual and Environmental Moderators

The reader will also note the inclusion of individual- (e.g. sex, ethnicity, personality traits) and environmental contextual- (e.g. neighbourhood, climate) level factors, which we hypothesise might moderate the association between PL and PA [17], and between adaptive physiological responses and health (disease) outcomes. Factors such as sex or socioeconomic status will likely influence the transition between PL and whether or not it leads to PA participation. There is evidence, for example, that the relationship between fundamental movement skills and PA later in life is conditional on sex [23]: such skills may be more important for girls' participation than for boys [24]. Also, the physical and social environment (context) will influence opportunities for engagement in PA [17], thereby influencing the impact PL may have on participation [25]. For example, a major proportion of the dynamic systems theory is that the execution of a motor skill(s) is influenced by interactions among the individual, the environment (physical and/or social) and the nature of the task itself [26].

Individual and contextual factors moderating the association between PA, adaptive stress responses and health outcomes remind us that the impact of PA is contingent on other processes (i.e. genetic, social, environmental) that impact health, both independently and synergistically. Regular PA is reportedly decreased in high-risk neighbourhoods (e.g. high violent crime rates) due to victimization, reducing other possible health benefits [27]. Among individuals at risk for cardiovascular disease, high levels of physical fitness may reduce the risk of death, whereas low levels of fitness at the same level of risk may increase it [28, 29]. Both of the examples suggest moderating roles for fitness and for aspects of the environment on health outcomes related to physical (in)activity.

2.4 Contrasting Our Model with Existing Models of Motor Development and Health

Our model does share some similarities with existing models. For example, Stodden et al. [16] presented a model linking motor competence—perceived and actual—to PA engagement and body weight. In their model, they depicted positive and negative spirals, reflecting that the associations among these variables is reciprocal and reinforcing over time. Hands et al. [30] and Cairney [31] similarly presented a negative feedback-type loop linking low motor competence to physical fitness and hypo-activity in children, while acknowledging that the spiral of effects is further influenced by individual, social and environmental factors. Recently, Hulteen et al. [32] presented a model outlining the developmental progression from reflexive and rudimentary movements to fundamental movement skills and, eventually, specialised movement skills that facilitate lifelong participation in PA. Individual-level factors, such as physical fitness, self-efficacy and perceived competence, influence and are influenced by the entire developmental process. Importantly, Hulteen and colleagues [32] placed particular importance on the physical and social environment in either hindering or promoting the transition from rudimentary to more fundamental skills.

The differences between our model and these examples lie in the explicit theorising about PL as a concept beyond only movement competence or movement skill. Stodden and

colleagues' [16] model, for example, stops short of linking movement skill to affect and motivational factors beyond perceived motor competence (PMC). Hands et al. [30] limit their theorising to individuals with poor motor coordination. While these models do consider individual factors such as motivation to be present, they stop short of the full range of affective and social factors that are included in the conceptualisation of PL. In this sense, while there is great utility in these models from a motor competence and health perspective, they do not include other psychological and experiential elements that are important for understanding the progression from motor skill to health outcomes. One important limitation is their rather narrow focus on PMC as the central construct in the motivation domain.

2.5 Expanding the Conceptualisation of Motivation in the Context of Physical Literacy

Motivation is a critical factor in supporting regular engagement in PA necessary to accrue health benefits. Beyond Susan Harter's competence-based theory, motivation has also been found to be influenced by levels of self-determination [33]. Self-determination theory (SDT) considers the extent to which behaviours such as PA participation are undertaken volitionally or are controlled by some external agent [34]. In part, SDT and the level of self-determination can range along a continuum from 'amotivation', when a person lacks motivation and perceives no connection between engagement in PA and the outcomes associated with its actions, to intrinsic motivation, where people are considered highly motivated as they engage in PA because they find it enjoyable, interesting and stimulating. Indeed, enjoyment (whether it be of physical education classes, sport or exercise) or affective attitudes and affective responses are considered among the most robust predictors of PA behaviours [35–37]. Findings from a recent systematic review suggest that intrinsic and more autonomous forms of motivation are critical determinants of sustained engagement in PA [38].

In addition to self-determination, the psychology literature has continuously demonstrated self-efficacy to be a consistent predictor of PA regardless of the sample population [21]. Similar to the motor competence literature, these factors have often been viewed independently as discrete factors within various social cognitive theories. Critically, these individual-level psychological factors are all considered amenable to change and can be prompted through emphasis on fun, skill improvements, personal accomplishment and achievable challenges conducted in supportive environments.

It is understandable that the focus on many of these 'higher-order' social cognitive theories has been less influential in shaping theory about the social and psychological domains that influence motor development in young children, owing largely to the fact that children under the age of 8 years lack reflective self-awareness with regard to constructs such as identity or appraisal of self-efficacy [39]. With PL, however, the emphasis is on not only the early childhood period but the life course as a whole. Therefore, it is important to ensure that, like motor development, we view motivational constructs within a developmental framework, where different motivational domains emerge over time as children age with greater complexity, and with correspondingly more salient effects on participation.

2.6 Physical Literacy Across the Life Course

Finally, the overarching arrow at the top of the model is intended to add an explicitly developmental element into the model (see Fig. 1), suggesting that PL development, particularly early in life, will influence subsequent PA participation and related outcomes across the life course, reinforcing the idea of PL as a lifelong journey [40]. We also include a pathway linking chronic health problems back to PL. Later in life in particular, the onset of chronic, degenerative physical health problems (e.g. arthritis) may restrict movement and movement opportunities, forcing adaptations to movement behaviours; it will also impact the ability to acquire new movement competencies and the affective and motivational dimensions connected to movement experiences. The process shown in Fig. 1 should be considered within the developmental context—one that includes complex and reciprocal associations over time.

While we certainly do not claim this model to be exhaustive, the purpose is rather to provide a generalised evidence-informed conceptual framework to facilitate ongoing theorising and empirical testing of the potential links between PL, PA and health.

3 Existing Evidence Linking Physical Literacy and Health Outcomes

As is common in emergent fields of study, there have been more papers attempting to define the concept than there have been papers studying the phenomena—including its potential consequences such as health and well-being. The exception to this is the field of measurement, where there has been some study of the measurement properties of tools purported to measure PL [41]. In light of this state of affairs, we cannot present direct evidence of the associations between PL, PA and health. However, we believe there is evidence from other fields that warrants deeper consideration and that provides some justification for positioning PL as a determinant of health.

4 Developmental Coordination Disorder as a Case Study in Physical Literacy and Health

While historically it has been known by many different names (e.g. dyspraxia, motor learning disorder, clumsy child syndrome) [42], developmental coordination disorder (DCD) has become the preferred label for children who present with motor coordination difficulties that significantly impact everyday functioning, but for which there is no known medical cause (e.g. cerebral palsy, muscular dystrophy, head trauma or brain lesion) [43]. DCD is known to significantly interfere with activities of daily living, academic achievement and PA pursuits [44]. Affecting between 2 and 5% of all children [45], it is one of the most prevalent childhood disorders [46].

DCD serves as an illustrative case for considering the impact of PL on health; indeed, children with DCD represent a group for which the development of PL has been significantly compromised. More specifically, we can readily identify elements of each of the core domains of PL embodied in children with this condition. Table 1 below shows this more specifically.

As Table 1 illustrates, there is existing evidence that DCD is associated with all of the stated core domains of PL. If we imagine a hypothetical child with the disorder, we can see in him/her the embodiment of this *multidimensional, experiential convergence* concept, albeit in extreme and negative form, when we consider mapping the concept of PL onto evidence on DCD from the literature. Firstly, the hallmark feature is impaired motor coordination, which has a direct and pervasive negative effect on the development of movement accuracy and speed [47], and what have been broadly defined as fundamental movement skills [48]. Children with DCD find running, hopping, skipping, jumping and the coordinated actions required for participation in physical activities extremely difficult and present with motor development substantially below that of typically developing peers [43]. Children with DCD, particularly during middle to late childhood and adolescence, hold negative perceptions of their athletic and motor competencies and overall self-concept [48]. They are acutely aware of the difficulties they have with motor-based activities, and this is well-reflected when they are asked about their perceived abilities. Children with DCD, likely due to repeated struggles with everyday taken-for-granted activities requiring motor coordination, from tying shoelaces to doing schoolwork to participating in physical education, tend to disassociate pleasure and enjoyment from motor-based experiences [49]. Children with DCD also tend to withdraw from social–physical activities [50], preferring more solitary activities that demand less motor skill (reading, watching television, playing video games) [51] and reporting less enjoyment in organised forms of activities (e.g. physical education, sport and recreational programmes) [46]. They also tend to be less motivated to be physically active, reporting lower levels of perceived motor coordination [48] and lower self-efficacy toward PA [52]. Children with DCD are more likely to be socially isolated [50], and in the school yard are often the victims of teasing and bullying [53].

When considered in its totality, all of these factors converge to increase the risk of a variety of mental and physical health problems among children with the disorder. First and foremost, physical inactivity is prevalent in children with DCD—compared with their typically developing peers, children with DCD are much less likely to participate in free play and/or organised sport and PA [52, 54]. The concern is that high rates of inactivity in this population increase the risk for diseases associated with chronic hypo-activity [55]. Children with DCD have been shown to be at much greater risk for overweight and obesity [56], metabolic syndrome [57] and poor physical fitness [55, 58], all of which are risk factors for cardiovascular diseases, diabetes mellitus and some cancers later in life. Children with DCD also appear to have poor perceptions of self-worth and perceived social competence [53], both of which are risk factors for mental health problems: research has shown DCD to be associated with increased risk of depression and anxiety [59], as well as other psychosocial outcomes such as adjustment to formal schooling [60].

In summary, in children with DCD, we see the combined impact of poor motor competence, negative affect and

Table 1 Mapping the construct of physical literacy onto the experience of developmental coordination disorder

Domains of physical literacy	Children with DCD
Motor competence	Show significant impairment in motor skill, both gross and fine motor, and balance [43, 47]
Self-concept and affect	Often report negative self-concept (self-esteem, self-worth), and hold negative perceptions of their motor abilities [48] and report low levels of enjoyment in sport and physical education [46]
Motivation	Report poor self-efficacy toward PA [49], and rate their motor competence as low relative to typically developing children [48]
Social/experiential	Are more socially isolated than other children, and more likely to experience verbal and relational victimisation [50]

DCD developmental coordination disorder, *PA* physical activity

motivation on PA, which in turn is associated with poorer physical fitness and several physical and mental health-related problems. We also see the influence of social factors, particularly social isolation, teasing and bullying, and the impact this has not only on participation but health as well. Given that these same elements map very closely onto the concept of PL, we argue that DCD well represents the potential negative impact of low PL on health, consistent with the model presented earlier (see Fig. 1). Further, and consistent with our model, the literature has shown that individual and contextual factors may moderate the associations between DCD, PA and health-related outcomes. For example, the effect of DCD on participation in organised activities and free play is not the same for girls and boys [54]. In a longitudinal study of children with and without DCD, while overall participation rates in active organised and free play were lower in children with the condition, boys with DCD increased participation over time (although never reaching the level of participation of boys or girls without DCD), whereas participation remained unchanged over time in girls with the disorder [54]. Framed in the context of PL, we see in children with DCD this negative loop of poor motor skill, low competence and confidence, and the negative impact this has on PA and subsequent health outcomes. At the same time, we do not mean to imply to children with DCD have poor PL. As Whitehead [4] has argued, PL can be viewed as an individual journey, where one's own abilities and capabilities are considered and development is viewed as progression at the individual level, not in comparison to an external norm or standard. Children with DCD can and do participate in a range of activities, and they can and do learn new skills that afford greater participation, even if they never reach the same level of proficiency as children unaffected by the condition.

When considered from the perspective of motoric ability, children with DCD represent the low end of motor functioning along a continuum—the bottom 5th percentile on a standardised test of motor coordination. PL and motor competence in general, however, are concepts that encourage us to think more broadly across the entire spectrum or range of abilities and dispositions. Therefore, we may ask whether the impact of poor PL—embodied in the case of DCD—the only example where we may see negative health outcomes? Next, we turn to the more general motor development literature—where the focus is usually on typically developing children—and examine evidence that might support the PL and health association.

5 Motor Competence, Physical Activity and Health

Stodden and colleagues [16] published a model linking PMC and actual motor competence (AMC) to PA and health-related outcomes, in particular (un)healthy weight. Since that first publication, a number of studies have examined specific pathways identified in the model [23, 61–63]. The link between motor competence early in life and PA later in development, perhaps the most important of these, has been supported by at least two longitudinal studies [64, 65]. For example, Barnett and colleagues [64] found that higher scores on object control skills assessed in childhood predicted about 4–18% of the variance in moderate-to-vigorous PA in adolescence. Importantly, there may be a specificity effect of motor competence as locomotor skills assessed in the developmental period did not predict PA in adolescence. The developmental period may also moderate the association. A recent systematic review of the evidence concerning the links between motor competence and PA concluded that there is a low to moderate relationship in early childhood and adolescence, and a low to high relationship in middle to late childhood [63]. Overall, however, we have substantial evidence that motor competence is related to PA from childhood to emerging adulthood.

A critical question still remains whether the existing evidence can link motor competence to health outcomes. Since the publication of Stodden and colleagues' [16] model, a number of studies have demonstrated links in typically developing children between motor competence, (un)healthy weight and various markers of physical fitness. Robinson et al. [61] concluded in their recent systematic review that there was clear evidence of positive associations between motor competence and cardiorespiratory fitness, muscular strength and endurance, and body weight. At present, there are limited data on the developmental associations between motor competence and health-related fitness, but, as with PA, there may be sensitive periods when the impact of motor competence on fitness is stronger. One review suggested that there is strong evidence for a moderate-to-strong association ($r = 0.27$–0.68) between motor competence and aerobic and anaerobic (muscle strength and endurance) fitness in middle to late childhood and adolescence [66]. Less work to date, however, has focused on early childhood. King-Dowling and colleagues [67] recently showed that 4- and 5-year-old children with below average levels of motor coordination performed significantly worse on tests of anaerobic and aerobic fitness when compared with typically developing preschoolers. Importantly, PA, measured using accelerometers, did not mediate that association. This supports the model presented by Stodden et al. [16], suggesting the development of motor competence and fitness may precede PA participation in early childhood. It is also likely the case that because the motoric demands of active play are relatively low in this developmental period, poorer motor ability and lower fitness do not act as significant barriers to activity in the way they might as the motor complexity of PA increases with age [68].

Taken together, there is consistent evidence concerning the importance of movement competence to PA and motor competence to health-related outcomes in children and adolescence, all of which supports the main pathways identified in Stodden and colleagues' [16] model. From the perspective of PL, this evidence at best provides only partial support for the argument of a link between the holistic concept of PL and health: motor competence, while integral to PL, is not the only domain included in the concept. In Sect. 6 we review two recent studies that take a more direct approach to capturing the multidimensional nature of PL, moving beyond the focus on specific components such as motor competence, to a more integrative, comprehensive approach.

6 Modelling Approaches Consistent with the Concept of Physical Literacy

Although the Stodden et al. [16] model hypothesises interrelationships among PMC and AMC and PA and health, most studies have examined these either as separate individual pathways or using sequential (mediating) models. An alternative approach, one that is consistent with the concept of PL, is to see if these motor–cognitive–affective factors work synergistically, rather than additively or independently. Analytically, there are a number of different ways to approach this: testing for interactions, creating high-order latent constructs via structural equation modelling or using data clustering techniques. Recently, at least two of these approaches have been applied. In this section, we consider two prominent examples from the literature.

De Meester and colleagues [69] used a 'person-centred' approach to examine whether there are unique profiles of PMC and AMC in childhood and whether these profiles relate to PA and weight status. Arguing that previous research has relied on variable-centred analysis to explore the additive effects of PMC and AMC, the researchers turned instead to cluster analysis to determine whether unique groups of children can be identified, based on combinations of PMC and AMC. Three groups were identified using this approach: high PMC–high AMC; low PMC–low AMC; and high PMC–low AMC. Children in the high PMC–high AMC group reported high levels of PA (measured using accelerometers) and low body mass index (BMI) when compared with the low PMC–low AMC group. Interestingly, the high PMC–low AMC group had PA levels comparable to the low PMC–low AMC group, but there were no differences in BMI between this group and the others. By attempting to consider the simultaneous effects of both PMC and AMC, this paper approximates a PL approach, albeit limited to competence only. Future work can build on this approach by incorporating other domains consistent with the concept such as positive affect (e.g. enjoyment) and other dimensions of motivation (e.g. confidence). Cluster analysis, or 'person-centred' approaches are definitely an appropriate choice for future research on PL.

Cairney and colleagues [70] took a different approach, using confirmatory factor analysis to determine whether a single latent factor—PL—could be identified using items from a number of different scales/measures, each measuring a different domain of PL (motor ability, motivation and enjoyment/affective), collected from the same children. Their results supported a two-level latent model of PL, comprised of the four lower-order latent constructs: motor ability (proficiency), predilection toward PA, perceived competence and enjoyment of physical education (see Fig. 2 for a hypothetical model of the factors observed in their data). Importantly, they found the factor structure to be consistent in two samples: children in grade 5 (mean age = 10 years) and grade 7 (mean age = 11 years) in the public school system in Canada.

Using the same data as Cairney et al. [70], we constructed a simple additive measure of PL based on the model identified by adding all the single items (represented by the boxes at the bottom of Fig. 2) together. This is consistent with treating PL as a latent construct by creating a composite scale (in this way, we obtained a single measure capturing items from each of the subdomains identified in their model but there was no weighting of individual of items). We then examined correlations between this composite measure and the Bruininks-Oseretsky Test of Motor Proficiency (short form) (BOT-sf), which was one of the measures used to construct the model, with self-reported PA (using the Participation Questionnaire [PQ] [71]) and peak maximal oxygen uptake ($V0_2$) (estimated from the 20-m shuttle run test [72]). In this case, higher scores on the scale represent higher levels of PL. The results are shown in Fig. 3. While there is obvious overlap (shared correlation) between the two measures (items from the BOT-sf are included in the composite measure of PL), the results are nonetheless intriguing. The correlations between our measure of PL and the BOT-sf with peak $\dot{V}O_2$ are similar ($r = 0.54$ and 0.53, respectively); however, the correlation between PL and PA doubled that of the simple correlation involving the BOT-sf ($r = 0.44$ vs. $r = 0.22$). All of the correlations were significant at $p < 0.01$. These results suggest that our composite measure of PL is more strongly related to PA than motor ability alone. While this may seem straightforward, given that the composite measure includes items related to affect and motivation, both of which we expect would be correlated with PA [73, 74], in addition to motor ability, it is important to remember that these were treated as a single unified construct (single scale), consistent with the results of the confirmatory factor analysis. In other words, there is empirical support for treating these measures as part of single concept, consistent with the definition of PL.

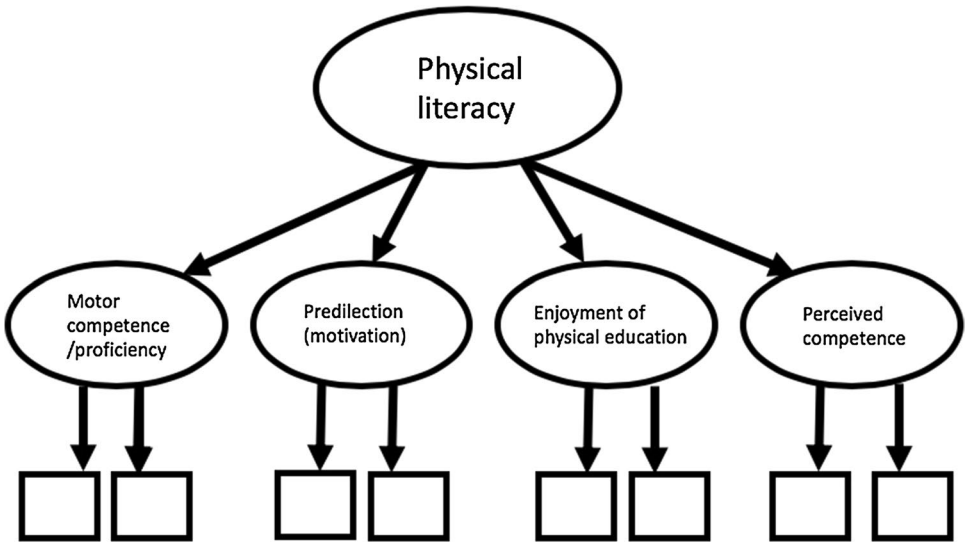

Fig. 2 Latent concept model of physical literacy based on the analysis presented in Cairney et al. [70]. The empty boxes at the bottom represent observed or measured items (e.g., item on a questionnaire tapping into motivation or a test item on a standardized motor assessment) under each latent (not directly observed) construct

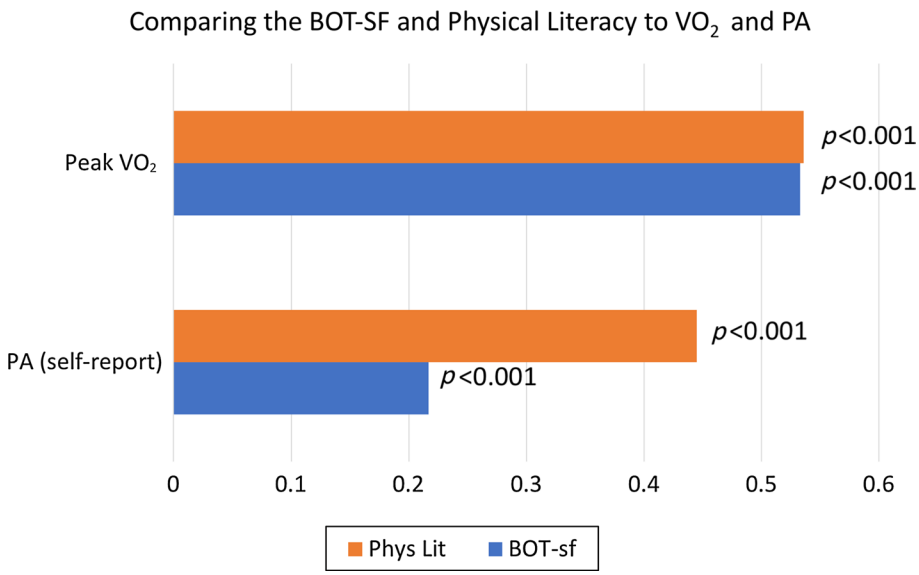

Fig. 3 Correlations between the BOT-sf, a composite scale of physical literacy and peak VO_2 and PA. *BOT-sf* Bruininks–Oseretsky Test of Motor Proficiency (short form), *PA* physical activity, *Phys Lit* physical literacy, VO_2 maximal oxygen uptake

Both of these approaches—confirmatory factor analysis and cluster analysis—support the idea that measures related to motor competence, motivation and positive affect work in an integrative manner to produce differences in PA and subsequent health outcomes in children. Unlike previous work that has treated these as discrete variables, these studies offer a different model and approach—one that is conceptually consistent with the PL concept. However, we know of no research that has extended beyond health-related fitness—as indicated in our model—to examine mental and physical health outcomes such as depression/anxiety or diabetes.

7 Discussion

PL is often positioned as the gateway to lifelong participation in PA [75, 76]. Evidence for the health benefits of PA is well-established and increasing PA is regarded as an important target for health promotion and disease prevention strategies [22]. It is hardly a conceptual leap to postulate PL as a logical and fundamental determinant of health, through its formative role in shaping lifelong trajectories of PA participation. Yet the explicit links between PL, PA and health and disease have not yet been comprehensively theorised or tested.

In this paper, we proposed a conceptual model, linking these constructs together while recognising the influence of other factors at the individual and contextual levels that may influence the process (see Fig. 1). We then reviewed select research from two bodies of literature that illustrates and supports the linkages across these constructs, in a manner consistent with the model. As such, while there is no direct empirical test of the effect of PL on health to date, there is some evidence supporting the plausibility of an association [77]. Moreover, recent work has started to use analytical techniques that allow for consideration of the integrative effects across the multiple core domains of PL on both PA and health-related fitness [69, 70]. These latter approaches are most promising because they support the idea that some of the core components of PL—particularly motor competence, motivation and affect—may indeed work inter-dependently to affect PA behaviour and, by extension, health outcomes. As more work on the measurement of PL continues to develop [78], it should be possible in the future to begin to examine the associations among direct measures of PL that include all of the core domains and health and behavioural outcomes. Until such time, it seems reasonable to use existing measures that map onto the core domains, but to analyse data using statistical techniques that consider the combined effects of these factors such as variable-centred and latent-variable modelling [69, 70].

At the outset of this paper, we acknowledged a perspective in the literature that downplays the notion of using PL as a means to achieve other ends [1, 4, 11]. To propose a conceptual model linking PL to health is to break with this tradition, and this demands at least some consideration of the benefits (and pitfalls) of taking this approach. With regard to the former we see the following four possibilities.

First, as noted already, there seems to be increasing cross-sectoral interest in PL, particularly in the field of public health [2], which moves the concept further from its traditional roots in physical education. Given the rapid accrual of evidence on the economic and health impact of inactivity [79–81] and the increasing positioning of inactivity as a public health crisis, PL through its association with PA could play a role in reducing long-term health repercussions. Positioning PL within the narrative of health promotion and disease prevention provides opportunities, at conceptual and practice levels, to build inter-sectoral collaborations between physical education, health promotion and public health [2].

Second, attempting to theorise about and empirically test associations among PL, PA and health (and disease) opens up new avenues for inquiry. Because PL is so rooted in pedagogy/education, consideration of how best to support the development of PL, particularly in childhood, opens up broader questions regarding the linkages between education and health at a population level (e.g. what community-based infrastructure is needed to support diverse and meaningful movement-based experiences for children?).

Third, placing PL in a health and disease context opens up new potential funding sources for research. In most Western countries, the budgets for health and healthcare research dwarf other funding streams by a considerable margin. If physical and other educators, as well as community sport and recreational experts, demonstrate a role to play in health promotion and disease prevention via PL, there is greater opportunity for funding from sources not traditionally accessed by these disciplinary groups.

Finally, if physical educators and PA researchers can have a voice at the health table through PL, then the potential for broader impact—beyond, for example, the context of physical education alone—increases significantly. Although not without its critics, concerns over obesity, sedentary behaviour and the increasing prevalence of chronic health conditions such as type 2 diabetes, cardiovascular disease and stroke have legitimised a role for PA researchers in this space. PL too has a similar legitimating potential, this time inviting others (physical educators, sport and recreation professionals) to participate in debates about the determinants of health.

8 Conclusions

Positioning PL as a determinant of health is not necessarily a new idea, but, to date, there has been little conceptual attention paid to what this means. In providing an evidence-informed model, our hope is to both encourage further discussion and stimulate empirical research. This paper then represents but a starting point—one designed to open new avenues of theorising and research.

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Compliance with Ethical Standards

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