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PHYSICAL LITERACY: IMPORTANCE, ASSESSMENT AND FUTURE DIRECTIONS

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Abstract

Physical Literacy (PL) has become a major focus of physical education, physical activity and sports promotion world-wide. PL is a multifaceted conceptualisation of the skills required to fully realise potentials through embodied experience. Substantial financial investments in PL education by Governments are underpinned by a wide range of anticipated benefits including expectations of significant future savings to health care, improved physical and psychological well-being of the population, increased work-force productivity and raised levels of expertise in sport and exercise participation. Disappointingly, however, scientific evidence showing the efficacy of PL interventions to successfully meet such high expectation is limited. We suggest that contradictions in research findings are due largely to limitations in movement assessment batteries and consequent discrepancies between measurements used to assess the immediate outcomes of PL programmes. Notably, there is no robust empirical tool for evidencing skill learning in the physical movement component of PL education and this presents a serious limitation to the design of, and claims which can be made for, such interventions. Considering the parameters of proficient PL skills and the limitations of current evaluation instruments, possible future directions for developing empirical measures of PL movement skills are presented.

1. Introduction

Physical Literacy (hereafter PL) is a multifaceted conceptualisation of the skills required to fully realise potentials through embodied experience [1]. The concept originates from existential and phenomenological philosophies and considers PL as a crucial component of human existence; a construct which enables individuals to lead a fulfilling life through enriching embodied experiences [1]. Reflecting this contention, the UK, Canada, Australia and New Zealand have recently pioneered large scale initiatives in education, community and public health settings to promote participation and performance in physical activities (PA) through PL. For example, during 2013 Australian Government invested $200 million Australian dollars to develop and implement programmes that promote PA [2]. Future savings for health care resulting from improving the population's PA in Australia were estimated to equate to $13.8 billion [2]. Therefore, the considerable expense of implementing PA programmes seems justified when the potential return on investment is considered.

Given the perceived importance of PL for improving PA engagement, it is unfortunate that current models used to operationalize this important concept and dictate the structure of PL programmes currently lack an accepted governing standard and vary in interpretation across the globe. Without comparative data to generate evidence for best-practice in developing PL skills, policies can only offer vague guidelines [3]. If PL is as important as claimed [1], then a robust empirical evidence base would seem long overdue. Accordingly, we present a critical consideration of the evaluation of PL, in order to examine options for enhancing the evidence base. To source relevant available literature, electronic databases (Science Direct, PsychInfo, Wiley) were searched using the terms 'motor-skill' OR 'movement skills' AND 'physical literacy'

OR 'physical education' AND 'assessment' OR 'evaluation'. Abstracts were examined and relevant articles were further examined if they included a measure of physical skill competence used to test physical ability in children.

2. Physical literacy as the primary focus for Physical Education

Physical education is an almost ubiquitous resource provided by schools to teach physical skills and promote physical activity. Research investigating the influence of skill development on parameters of physical activity later in life shows contrasting results [4-8]. One reason for the contradicting research findings appears to be the wide variety of assessment tools employed to test the physical skill component of programmes designed to promote life-long physical activity. In the absence of a 'gold standard', the variation in methods for assessing interventions has arguably impeded the development of further longitudinal studies and led to interventions that encompass a broad variety of definitions and objectives [4-8]. These issues are summarised through exemplar different PA programmes across the world in Table 1.

Intervention	Objective	Setting	Assessment
CS4L (Canada Sports 4 Life)	Develop physical literacy through sport and athleticism based on stages of Long Term Athlete Development model	Sports clubs & community	Physical Literacy Assessment for Youth
Skills 4 Sport (Northern Ireland)	Learning key movement skills leading to development of sport specific skills	Sports club & community	McCarron Assessment of Neuromuscular (MAND)
Start to Move (UK)	Primary schools based interventions for training teachers/coaches to deliver PL education	Schools	Provides guidelines and training to for te assess movement skills based on fundame
Basic Moves (Scotland)	Basic/ fundamental movement development	Sports club & community	Test of Gross Motor Development TGMD
Kiwi Sport (New Zealand)	To develop fundamental movement skills and progress to educating modified sports specific skills	Sports club	Non-standardised ('invented') games use and combined motor skill level marked o per/lower/body skills
Nike Designed to Move (USA)	Universal programme to promote fundamental movement skills	Schools, sports club and community	Provides a database for club, community, to report effectiveness.

Table 1 Review of PL interventions and assessments

Whitehead's [1,9] model describes the behavioural, psychological and physical components that encompass PL: Psychological correlates include perceived competence, enjoyment and belief that engaging physical pursuits is worthwhile [1]. Behavioural

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characteristics, such as goal setting, imagery, reflection, appear to play a crucial role in the realisation of potential by enabling individuals to invest the requisite time to practice, avoid distractions, and stay committed to pursuing personal excellence in PAs throughout life. Although distinct, the components of PL are inter-linked i.e. physical skills are required to utilise psychological and behavioural concomitants of PL. Notably, however, while the psychological and behavioural components have achieved some consistency of understanding, the physical component remains obfuscated by the variety of measurements used in its operationalization. Explicit focus on physicality is a feature of Whitehead's [1] original ideas, which categorised PL movement skills into three movement capacities (i.e. fundamental, combined and complex movement capacities). However, the exact balance of physical capacities required to attain *proficient* PL has yet to be clearly expressed. A summary of generally accepted physical movement capacities is shown in Table 2.

Simple movement capacities	Combined movement capacities	Complex movement capacities
Core stability	Poise (both balance and core stability)	Bilateral coordination
Balance	Fluency (coordination, balance and proprioception)	Inter-limb coordination
Coordination	Precision (accurate placement of the body and core stability)	Hand–eye coordination
Flexibility Speed variation	Dexterity (coordination, accurate placement and flexibility)	Control of acceleration/deceleration

Control	Equilibrium (balance, core sta-	Turning and twisting
	bility and movement control)	
Proprioception		Rhythmic movement
Power		

Table 2 – Summary of physical movement capacities

Our point is that, in the absence of evidence based guidance, programmes to provide PL education may focus (we suggest erroneously) on developing simple movements. At first sight the attention to simple movement capacities seems sensible. Well-founded generic athletic abilities (e.g. balance, locomotion, strength) underpin almost all physical pursuits [10-12]. Developing fundamental movement competence is imperative to perceived competence and confidence that is associated with improving and increasing PA and correlates with physical fitness levels in adolescents and adulthood [13]. Whilst basic movement skills are undoubtedly imperative, however, their role in PL education requires consideration *if* the objective is to promote higher order motoric competence. For example, neither balance (static, reactive or proactive) nor strength shows statistically significant correlations to functional performance tests (e.g. timed 'up and go') [14]. Combining basic movements is essential to engage in advanced physical experiences in a variety of domains. For example, Seifert and colleagues, [15] show that adaptability and variation in combinations of motor patterns enable individuals to display mastery in previously learned movements and gain new movement knowledge from executing motor skills in a variety of *novel* combinations. Our point here is that the current popular emphasis on fundamental skills may not be appropriate for realisation of the benefits claimed for PL. As such, PE programmes, guided ideally by evidence, should be ensuring the development of more

sophisticated elements of motor coordination, as shown in the right hand column of Table 2. Of course, the veracity of such suggestions awaits the development of more accurate measures of PL.

3. Evaluating Physical Literacy

In addition to the lack of comparative data due to non-standardised testing (Table 1), skill learning 'confounds' the external validity of action-based longitudinal PL research to date [16]. In the context of PL, assessment should test self-regulated execution of gross motor coordination in a range of tasks to measure individuals' strengths/weaknesses, including specific evidence of learning and skill progression to track development over time. However, movement assessment batteries most commonly used in research were designed to test for motor development impairment [17,18]. Assessment batteries use either 'product' or 'process' focused methods to examine movement skills. Product focused measures offer objective information indicating the time taken or the number of trials an individual needs to successfully complete a predetermined task (such as the Movement Assessment Battery for Children: "M-ABC"). Such tests constrain movement to set time, space and procedural parameters. Product focussed assessments have been criticised for lacking the sensitivity required to detect individual differences in movement abilities considering the idiosyncratic nature of optimal motor pattern execution [19].

Process orientated assessments examine movement quality and provide valuable movement data: however, reliability confounds are present due to the influence of assessor experience and subjectivity on test scores[18]. Also, environmental constraints influence testing procedures (equipment used) and the performance of the in-

dividuals being assessed (e.g. assessor relations, noise, audience observation etc.). Despite their clinical origin, these movement analysis procedures are increasingly adopted in education and sports settings as a general assessment of motor ability by coaches, teachers and researchers.

Furthermore, the validity, reliability and sensitivity of applying battery assessments to test movement are limited without considering the contextual inferences of the test [16,20]. In the context of an appropriate movement-based PL assessment, the current batteries have a number of limitations. For example, the Test of Gross Motor Development 2nd edition (TGMD-2) provides a summative score for the performance of separate motor skills: The individual receives a score of 1 if the skill is completed and 0 if not. This seems a rather 'black and white' but contrastingly subjective evaluation of a surely continuous variable! The TGMD-2 also constricts movement skills to a specific context i.e., a skill level deemed fundamental for normal motor development. Skills considered fundamental to PL development should surely include more complexity and sophistication.

The context of movement ability remains constrained by set tasks and performance criteria throughout a number of battery tests. The M-ABC focuses on measuring balance, manual dexterity and ball skills using quantitative outcomes of trials completed within set boundaries. Take, for example, the object manipulation task, which provides information about an individuals' ability to throw a tennis ball in a certain predefined way (overhand). Notably, however, it does not depict a generalizable motor ability (i.e. the motoric competence required to adapt movement skills and throw an oval-shaped ball underhand). As highlighted earlier, these tests were originally intended for use in clinical setting as a discriminative measure to characterize motor *deficiency* [21].

There are also a number of pragmatic issues associated with the various tests. For example, the time requirements to perform individual assessment compromises practical application in schools settings. The M-ABC takes 20-25 minutes to test per individual and requires administration in a separate room [17]. Additionally, norm-based movement tests lack the flexibility required to monitor individual-specific progress in motor skill learning that varies as a function of age, gender and cultural factors [16,20,22,23]. As a cross-cultural example, the McCarron Assessment of Neuromuscular Development is a norm-based assessment originating from the US that has limited validity when used to test movement ability of Australian cohorts [16].

Movement assessments also predominantly involve skill-instruction guidelines or a demonstration by the tester prior to assessment [22]. As such, these tools provide results that *may* be more indicative of a demonstrator's expertise and/or a child's mimicry skills than the individual's knowledge, level and understanding of movement skills. This is not to say that reproducing a demonstrated movement is not an important component of PL; however, it is also not representative of an individual's ability to interpret task demands and select appropriate movements from their repertoire of motor competence in response.

The validity of assessments is further contested by a lack of consideration for the *relative* importance of factors contributing to physical proficiency. Reflecting our earlier comments, whilst developing a fundamental base of movement skills is essential, proficiency in combined and complex movement capacities are surely more imperative to becoming physically literate. Attaining sufficient competence in basic movements provides individuals with the motivation and perceived ability to participate and progress in PA [13,24]. However, some movement skills impact on future

progression and participation in PA to a greater extent than others. Gross motor-coordination accounted for 40% of the variance detected on discriminant tests used on children with and without motor impairment [18], whereas individual scores for flexibility, fine motor skills or locomotion did not show any significant relation to future levels of PA [24] or overall scores of motor ability [18]. However, motor skill assessments often aggregate components together in an unweighted total; i.e. each factor is treated as important as the next, even though some components are measured more often and, therefore, make a bigger contribution. Additionally, motor skill assessments typically require individual administration, demonstration and equipment making them challenging to implement in practical settings. As an example, the Bruininks-Oseretsky Test of Motor Proficiency, Second Edition (BOT-2) [21] is an individually administered, norm-based measure of fine and gross motor skills used to assess skill development. Finally but no less important, all of the evaluations which we have reviewed fail to test an individuals' ability to evaluate a task, then combine and adapt motor skills to novel environments, clearly a major expected feature of those presumed to be high in PL [1].

4. Implications of Limited PL Evaluation

The empirical evidence base supporting PL depicts contradictory findings that, we suggest, reflect either a flawed construct of PL or, more likely, inappropriate use or interpretation of movement data. If the primary objective of PL education is *life-long* physical activity (facilitated by physical proficiency), not immediate fitness gains, the outcomes of PL development initiatives should reflect these aims. Clearly, the behavioural, psychological and physical components of PL are (theoretically and practically) distinct *but interlinking* constructs. Integrating evaluation of the constructs

should provide a more accurate assessment of an individual's PL ability. Therefore, as iterated in our earlier arguments, an *appropriate* physical skill evaluation is required to meet the objective of integrated monitoring in *all* parameters of PL education.

Researchers have addressed the need for standardisation and clarification between measuring tools that report the same objective but which, confusingly, provide different information [25]. Process-focussed qualitative movement tests that provide standard definitions and descriptions to guide the tester and reduce subjective bias have also been developed [22, 26]. However, important movement capacities have often been omitted from qualitative measurements due to difficulties in observing certain characteristics (e.g., movement fluency). A possible caveat of including complex movement skills in evaluations is increased measurement error that reduces test reliability. Careful refinement will be required to produce reliable assessments of complex movement skills. Nonetheless, we suggest that such efforts must be made if we are to generate a valid and meaningful tool.

In short, research is required to establish appropriate procedures for testing movement ability that provide empirical monitoring on micro (individual) or macro (intervention) levels. This, in turn, should generate valid, reliable measures that reduce demands on resources without compromising the quality of data measured.

5. Future directions for enhancing PL Evaluation – the potential of "exer-gaming" techniques

Currently, the movement battery assessments used at present do not coherently link test outcomes to the objectives of PL education as conceptualised by Whitehead [1,9]. Specifically, the movement capacities that demonstrate deep and meaningful learning

of physical skills are neglected. Some assessment batteries used facilitate assessor ease but provide limited information that lacks objectivity and largely focuses on basic movement abilities.

As a new direction, and in order to address these various issues, we suggest that movement assessments which use commercially popular motion capture systems (e.g., Microsoft Kinect, Nintendo Wii, etc.) could provide a potential solution. Exer-gaming is a portmanteau of exercise and gaming used to describe video games that require physical body movement to engage in gaming activity. The exer-gaming phenomenon has become a recent focus of research in physical health, leisure [8,27-30] and clinical [31] contexts, albeit with mixed results. These issues notwithstanding, however, the exer-gaming technological platform may provide objective, accessible and sensitive methods of monitoring learning in the context of becoming physically literate, even if their potential as exercise stimuli is more limited. Furthermore adopting similar methods to assess movement in PE could potentially provide an ecologically valid, and child friendly/accepted measure to test the effectiveness of PL programmes. The rapidly increasing popularity of exer-gaming across the globe could provide a means of assessing and tracking motor learning that can be used comparatively across nations to establish an evidence-based protocol for designing and delivering quality PL education.

As stated, exer-gaming interventions have been tried although with mixed results. The Centre for Exer-gaming Research Canada (CERC) and CS4L have recognised the potential of exer-gaming technology to provide enhanced education, compliance, motivation and commitment to PE compared to traditional PE models, [29,32]. However, the impact of exer-games on PA levels and fitness vary depending on game

design and PA parameters measured. For example, studies found that exer-games designed to improve movement skills (e.g., balance) or using upper-limb only movement induced light-moderate PA levels [29,33]. In contrast, exer-games designed to engage whole-body movements (Dance, Dance Revolution) resulted in moderate-vigorous activity levels, energy expenditure and heart rate increases equal to traditional PA engagement (running) [33]. Exer-games also improved functional fitness in overweight children [33], although increased traditional PA and exer-gaming PA correlated with increased sedentary behaviour and no significant differences in overall activity levels compared to control groups [33].

In addition to the physical component, exer-gaming impacts the psychological and behavioural aspects of PL: 'On-line' visual feedback provides the opportunity for intrinsic task correction to facilitate motor-skill learning [35]. Motivation and enjoyment of PA participation increased through exer-gaming interventions compared to traditional PA particularly in 'at risk' populations [30, 33].

Given these mixed outcomes, the effectiveness of exer-games as a means of increasing PA clearly requires further research. However, as stated above, the use of exer-game technology could provide an appropriate method for assessing movement competence. Low-cost motion capture devices used in PE could enhance the quality of movement testing procedures, provide individualised, detailed feedback and allow longitudinal data-gathering to monitor motor-skill development. Exer-games currently used in education evaluate markers of physical fitness (BMI) or simple movement capacities (balance, postural stability) [35]. Exer-game technology provides scope for testing (and teaching) all PL parameters (behavioural, psychological and physical) across a range of levels (fundamental-advanced). Clearly, further longitudinal research is required to establish the optimal design of exer-games used to educate and

evaluate PL skills. Some examples of tasks that we are currently developing via the

exer-gaming platform to enhance the quality of PL testing are listed in Table 3. [33-

35].

Coordination Characteristic	PL Skills Involved	Description
Interceptive timing e.g. Basketball, tennis, baseball, cricket	Visual perception timing Control Unimanual & bimanual coordination Limb dominance Ballistic power	A bouncing ball is projected across the screen in front of the partici-pant. The participant has to 'strike' the virtual ball inside a highligh target zone on the screen using their hand/s. Each hand is tested separately and two hands together to measure bi manual co-ordination and hand dominance. Spatio-temporal coordination in interceptive actions between hand a ball are measured.
Object manipulation e.g. Archery	Visual-perception Hand-eye coordination Control Precision timing Fine motor skill	Pick up different sized balls and put them in a container using a virt crane controlled by the participants' actual hand movements testing spatio-temporal accuracy of the movement of the crane to the balls, and the co-ordination between opening and closing of the virtual 'claw'[35]
Locomotion and agility e.g. Gymnastics, athletics	Visual-perception Kinesthetic awareness Postural control Gross motor adaptation	Task requires quiet standing with feet together; standing shifting weight from one foot to the other as if making a step; normal walki and walking with changes in direction, level change (squat). Motio analysis sensors monitor movements of the head, top and bottom of spine, hips, knees, ankles and feet.
Rhythm and sequencing e.g. rugby, soccer, hockey, dance	Perception of rhythm Timing Intralimb coordination Stability of bimanual coordination	Learn a number of simple to complex rhythms/patterns and reprodu them with a bimanual tapping movement [36].

Spatial awareness and balance e.g. ice-skating, skiing, diving, gymnastics, track & field events	Visual perception Kinesthetic integration Imagery Planning Postural control Stability	Adopt and hold different spatial configurations of their body and lir to suit expanding apertures on the screen. Hence the task is somewh akin to a version of 'Human Tetris'. Sensory organisation and postu stability will be assessed via composite performance measures [36].

Table 3 - Examples of possible PL movement assessment tasks

We should acknowledge that there are still numerous barriers to be negotiated before exer-gaming can be considered as a potential alternative to movement assessment batteries to monitor movement competency on a large scale. As we have discussed, the physical capacities that are fundamental to PL need to be verified and weighted appropriately in accordance with the motor learning literature. In practical terms, the accuracy and sensitivity of commercial exer-gaming equipment requires rigorous testing against accepted motion analysis systems. Furthermore, the limited accessibility and acceptance of such technologies in certain countries and communities also needs to be considered as a socio-cultural constraint. Finally, one may also raise ethical concerns about the promotion of exer-gaming as the 'saviour' in the face of decreasing levels of physical activity and increasing childhood obesity [36]. We acknowledge the immediacy of the obesity epidemic necessitates PE that increases moderate to vigorous PA levels and physical fitness presently. We suggest that appropriately designed PE could, indeed, *should* combine moderate to vigorous PA with life-long physical skill learning. Alongside consideration of these barriers, the 'potential versus the actual' benefits of exer-gaming need to be verified [38] and it is hoped this article may help to provoke such research.

6. Conclusion

PL is a pertinent concept in pedagogical education terms and interlinks physical, psychological and behavioural skill learning. Adequate physical movement assessments would provide a more robust evidence-base to support the PL construct. Combining the advances in understanding in neuroscience underpinning physical skill learning and expertise with exer-gaming technology could provide accessible, appropriate methods for both teaching and monitoring PL education.

Some progress is evident. The current standardisation of monitoring methods [2] shows progressions in optimising evidence-based PL education. However, further development within PL education using exer-gaming programmes could improve the measurement of movement skills that reflect skill learning in *all* PL parameters and provide valid and comparable empirical data to assess effectiveness in PL education (e.g., Table 3). Further research is required to examine the effectiveness of exer-gaming applications for evaluating physical movement skills that reflect proficient PL.Such empirical evidence is required to test the validity of both PL and exer-gaming for providing optimal physical education.

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