



Development of the Physical Literacy in Adults Scale (PLAS)

Annaleise Naylor, Andrew Flood, Lisa M. Barnett & Richard Keegan

To cite this article: Annaleise Naylor, Andrew Flood, Lisa M. Barnett & Richard Keegan (2024) Development of the Physical Literacy in Adults Scale (PLAS), Journal of Sports Sciences, 42:12, 1099-1111, DOI: [10.1080/02640414.2024.2383486](https://doi.org/10.1080/02640414.2024.2383486)

To link to this article: <https://doi.org/10.1080/02640414.2024.2383486>



© 2024 The Author(s). Published by Informa UK Limited, trading as Taylor & Francis Group.



[View supplementary material](#)



Published online: 24 Jul 2024.



[Submit your article to this journal](#)



Article views: 4273



[View related articles](#)



[View Crossmark data](#)



Citing articles: 8 [View citing articles](#)

Development of the Physical Literacy in Adults Scale (PLAS)

Annalise Naylor^a, Andrew Flood^a, Lisa M. Barnett^b and Richard Keegan^a

^aResearch Institute for Sport and Exercise, University of Canberra, Canberra, Australia; ^bInstitute for Physical Activity and Nutrition, Deakin University, Victoria, Australia

ABSTRACT

Physical literacy relates to an individual's capacity to live a physically active and healthy lifestyle across the lifespan. Our understanding of physical literacy as a lifelong journey is hindered by a lack of valid measurement for adult populations. In response, we created a measure of physical literacy applicable to adults. A sample of 1180 adults answered a series of existing questionnaires assessing aspects of physical literacy. Using exploratory and confirmatory factor analysis techniques, we reduced the items to a 23-item six factor model, which had good fit to the data in both the exploratory analysis ($\chi^2(130) = 254.770$, $p < 0.001$; TLI = 0.965; RMSEA = 0.040 (95% CI: 0.031, 0.049)) and confirmatory analysis ($\chi^2(130) = 252.005$, $p < 0.001$; TLI = 0.957; RMSEA = 0.046 (95% CI: 0.036, 0.056)). The resulting subjective measure, the Physical Literacy in Adults Scale (PLAS), is a single psychometric measure applicable to adults aged 18–75 years. The PLAS covers four domains (physical, psychological, social and cognitive) of physical literacy to provide a holistic physical literacy outcome. The PLAS represents an appropriate way to assess adult physical literacy, providing an important first step in understanding physical literacy as a lifelong journey.

ARTICLE HISTORY

Received 20 November 2023
Accepted 16 July 2024

KEYWORDS

Physical literacy; adults;
measure creation; factor
analysis; psychometrics

Physical literacy is a multidimensional framework, which holistically examines an individual's capacity and commitment to a physically active and healthy lifestyle (Holler et al., 2019). The International Physical Literacy Association (IPLA) originally defined physical literacy as “the motivation, confidence, physical competence, knowledge and understanding to value and take responsibility for engagement in physical activities for life” (International Physical Literacy Association IPLA, 2017). More recently, Keegan et al. (2019) defined it as “lifelong holistic learning acquired and applied in movement and physical activity contexts”; emphasising the diverse, multifaceted benefits accumulated through engaging in physical movement. Beyond these foundations, physical literacy, as a framework, highlights the importance of lifelong physical activity behaviours (Dlugonski et al., 2022; Holler et al., 2019; Keegan et al., 2019). Comprising a self-reinforcing, virtuous cycle, physical literacy refers to the aspirations and capabilities of an individual to engage, and succeed, in physically active pursuits, as well as the resulting accumulation of physical, psychological and social wellbeing benefits (Almond, 2013; Edwards et al., 2017; Keegan et al., 2019).

The philosophical underpinnings of physical literacy vary across definitions (Martins et al., 2021; Young et al., 2023), with many researchers adopting the “Whiteheadian” approach, whereby physical literacy is monistic and an avenue through which lifelong engagement and learning occurs (Edwards et al., 2017). Similarly, in adopting the definition put forward by Keegan et al. (2019) in the current study, we view physical literacy not as a constant state, but rather an enduring and evolving process (Edwards et al., 2017; Green et al., 2018). As

such, while an individual's physical literacy can vary substantially at any given time, with understanding and application, an individual is able to renew-and-restart their physical literacy journey, following, for example, illness or injury (Keegan et al., 2019; Whitehead, 2013a, 2013b). Once on the journey to building their physical literacy, an individual can “draw on their integrated physical, psychological, cognitive, and social capacities to support health-promoting and fulfilling movement, relative to the situation and context throughout the lifespan” (Keegan et al., 2019). In addition to the work of Keegan et al., (2019) Cairney, Dudley et al. (2019) provide numerous specific examples pertaining to the integrative nature of the domains of physical literacy. In summary, the integrative nature of physical literacy allows individuals to identify, adjust and holistically apply physical, psychological, social and cognitive skills learnt in one setting (i.e., sport) to another setting, prompting lifelong enjoyment and engagement in numerous physical activities. Consequently, being able to monitor physical literacy may be a crucial prerequisite to understanding physical literacy across the lifespan.

Despite the often-discussed importance of lifelong development, empirical research investigating physical literacy has almost exclusively involved children and adolescents (Barnett et al., 2023; Dlugonski et al., 2022; Longmuir & Tremblay, 2016; Thermou & Riga, 2020). While early experiences are important to the development and trajectory of physical literacy (Robinson et al., 2015), understanding the totality of the physical literacy journey across ages and different developmental stages remains crucial (Longmuir & Tremblay, 2016). One pertinent issue hindering our understanding of physical literacy

across the lifespan, relates to the lack of appropriate tools for monitoring physical literacy in adult populations (Boldovskaia et al., 2023). A recent systematic review (Dlugonski et al., 2022), highlighted that without an adequate assessment tool, the charting and understanding of physical literacy – its antecedents and consequences – remains confined to child and adolescent samples, and does not allow researchers to account for lifelong development. As such, the need to develop a psychometrically sound physical literacy assessment tool for the adult population is paramount.

Recent cross-sectional studies (Elsborg et al., 2021; Gandrieau et al., 2023; Holler et al., 2019, 2021; Kleis et al., 2022; M. Y. Kwan et al., 2019; M. Y. W. Kwan et al., 2020; Liu et al., 2022; Ma et al., 2020) have begun to address measurement issues with varying success. For example, some studies (Kleis et al., 2022; M. Y. Kwan et al., 2019; M. Y. W. Kwan et al., 2020) have used modified child and adolescent physical literacy scales within young adult populations. Alternatively, Gandrieau et al. (2023) recently created the ELIP which provides a welcome attempt at providing a holistic physical literacy score. However, similar to the previous three studies (Kleis et al., 2022; M. Y. Kwan et al., 2019; M. Y. W. Kwan et al., 2020), the ELIP was originally developed for a younger, chiefly adolescent, sample and within an educational setting, which may not transfer to the adult population. Some studies (Elsborg et al., 2021; Holler et al., 2019, 2021; M. Y. Kwan et al., 2019; M. Y. W. Kwan et al., 2020) have created physical literacy measures for the adult population by drawing on other tools. For example, Holler et al. (2021) combined subscales from different measures to create a domain (i.e., motivation) measure. However, across all studies, the development and validation of the adopted measure(s) was not a central aim. Subsequently, the validity and reliability of item creation and/or selection in these studies was not always assessed, meaning that item selection methods, scoring, scale length, and assessment techniques vary greatly. Consequently, recent attempts to measure adult physical literacy present psychometric issues, which may not make them the most appropriate tool to progress the field.

Unlike the previous measurement attempts discussed above, the Perceived Physical Literacy Instrument (PPLI) (Sum et al., 2016) has been validated in an adult population. However, the instrument is heavily reliant on sports participation, and/or relates to general/overarching capabilities. Furthermore, the proposed three factor model of the PPLI (sense of self and self-confidence; self-expression and communication with others; knowledge and understanding) neither addresses all core domains of current physical literacy definitions (typically there are four of which the physical domain appears to be missing), nor does it provide a holistic measure of physical literacy – issues which are also prevalent in the senior perceived physical literacy instrument (SPPLI) (Liu et al., 2022). Given global definitions of physical literacy are multi-dimensional (International Physical Literacy Association IPLA, 2017; Keegan et al., 2019), the need for a multifaceted measure covering an array of “aptitudes” which can be integrated and scored as a single holistic measure of physical literacy is of high importance. The importance of such a measure has been highlighted in a recent review (Ryom et al., 2022), emphasising that while researchers have begun investigating assessment tools

for understanding adult physical literacy, a comprehensive, holistic measure is yet to be identified. Therefore, the creation of a valid and comprehensive assessment of adult physical literacy (spanning ages 18–75 years) is crucial.

There are challenges in the measurement of physical literacy in an adult population. To develop our understanding of physical literacy in adults, this study set out to identify if a single psychometric measure of physical literacy could be derived from previously validated research tools. At the forefront of this research was the development of an easy to implement, time effective and comprehensive tool. This study aimed to address the lack of appropriate measurement of physical literacy by developing and validating a new physical literacy measurement tool for adults.

Method

Rationale and design

The Australian definition of physical literacy was the guiding framework for this study, (see Keegan et al. (2019) for a comprehensive explanation, and schematic overview of domains and elements). We chose the Australian definition due to the holistic and inclusive aspects of the definition which both clarified and extended upon previous definitions (Martins et al., 2021). Additionally, the study was designed with adult physical activity in mind. Therefore, it was important to note that the selected measures (see below) did not exclusively focus on sport or competency-based activities (e.g., school/education), but rather measures needed to allow the individual to consider their own unique physical activity endeavours. We also drew on critiques of well-established measures such as the Canadian Assessment of Physical Literacy (CAPL) (Dudley & Cairney, 2022), to ensure our conceptual application of each domain was reflective of physical literacy. In line with previous physical literacy research (Cairney, Clark, et al., 2019; Dlugonski et al., 2022; Ryom et al., 2022), we chose to generate items using previously validated and widely used measures of constructs that align with theoretical domains of physical literacy (physical, psychological, cognitive and social) and their lower level elements (e.g., motivation, relationships, strength). The 30 elements of physical literacy outlined by Keegan et al. (2019) may not be feasibly assessed in a single measure of adult physical literacy, particularly when more than one item is used to measure each element. As such, we decided instead to focus our measure development on core elements that extend across the four theorised domains. Specifically, core elements of the psychological domain, including motivation and confidence, were selected because they are central tenants to physical literacy definitions (Martins et al., 2021). To align with validated measures of child physical literacy (Barnett et al., 2023; Shearer et al., 2021) and global definitions of physical literacy, content knowledge was considered a core element of the cognitive domain. In assessing the physical domain, items relating to elements of strength, coordination and balance were included as they represented global skills (as opposed to performance enhancement) required for movement activities which could also be assessed using

subjective and previously validated measures. Finally, assessing the social domain aligns with recent trends in physical literacy research (Jones et al., 2018; Martins et al., 2021; Petruševski et al., 2022), the relationships element was viewed as core because social interactions are seen as a key aspect of building one's social environment (Martins et al., 2021), with applicable assessment in the adult physical activity setting available.

For all measures included in this study, we chose to first test the complete scale(s), to ensure we respected the original reliability and validity of each measure. Nevertheless, in our desire to develop a new scale of adult physical literacy that meets accepted psychometric requirements, we retained the option to deconstruct any included measure during the modelling process, using the most salient items. Decisions regarding which subscales and items were retained in the new measure were guided by theoretical importance, the consideration of practicalities such as time for, and ease of, completion, and the results of the developing analyses. Likewise, decisions leading to the deletion of items are also explained with a focus on maintaining a manageable total scale-length and avoiding redundancy, while capturing the holistic integrative nature of physical literacy as opposed to the original premises of the individual scales.

In following the steps recommended by Boateng et al. (2018), we used factor analysis techniques to assess factor structures and reduce the number of items. We utilized both exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) techniques. In line with the Australian definition (Keegan et al., 2019), the physical literacy measure focused on the core tenets of physical literacy and did not include physical activity behaviours, which are positioned as an antecedent and/or consequence, but not inherent to the construct of physical literacy.

Sample

To recruit an adequate sample size, we drew on recommendations of Boateng et al. (2018) and Comrey and Lee (1992) and sought to recruit a combined total of over 1000 participants. To be eligible for this study, participants had to be 18–75 years of age at time of survey completion. The age range was chosen as it is inclusive of the varying age classification systems for adults across the world (Ouchi et al., 2017; Sanderson et al., 2015). To gain a broad adult sample, no other eligibility criteria were set. As outlined in the procedure section, throughout the data collection period, we implemented checks to ensure a representative sample was attained.

The final sample consisted of 1180 participants. The mean age of the sample was 37.02 (SD = 18.75) years. Of the total sample, 699 (59%) individuals identified with female/woman/femme pronouns, 394 (33%) of individuals identified with male/man pronouns, three individuals identified as non-binary, and one individual identified as other. The sample included participants residing in Australia ($n = 824$), the United Kingdom ($n = 169$), the United States of America ($n = 51$), New Zealand (n

$= 15$), Canada ($n = 11$), and South Africa ($n = 3$). Additional participants ($n = 27$) were from European and Asian regions, Supplementary file Table S1 provides additional demographic detail.

Measures

In creating a measure of adult physical literacy, we aimed to include items relating to the core elements of each of the domains of physical literacy. Items selected for item generation were chosen based on their alignment with the identified core elements of physical literacy (see Rationale and Design above). As motivation was considered a core element in the psychological domain, the Sports Motivation scale (SMS) was selected. Likewise, as confidence was also a core element of the psychological domain, we selected the Self-efficacy for Exercise scale (SEE). In assessing the relationships element of the social domain, we selected the Social Motivational Orientations scale for Sport (SMOSS). To assess content knowledge as a core element of the cognitive domain, we selected the Active Australia survey (AAS). Finally, to assess core elements strength, coordination and balance, we selected the Richards Physical Self-Concept Scale (RPSC). Additional information about each respective measure can be found below. Supplementary file Table S2 provides an overview of the original scale, its items and their mapping onto the theorised physical literacy domains and elements, highlighting the integrative nature of the chosen measures.

Demographics

We collected demographic details pertaining to age, gender, relationship status, highest level of education, country of current residency, Aboriginal and Torres Strait Islander (Australian indigenous cultures) status and employment status.

Active Australia survey (AAS) (cognitive domain)

We used the AAS (Australian Institute of Health and Welfare, 2003) to assess knowledge and awareness (content knowledge) of physical activity and health guidelines (cognitive domain of physical literacy). The survey includes eight questions to assess participation in various types of activities and five statements to assess awareness of current public health messages about physical activity. We utilised the physical activity component of this measure to assess predictive validity, as it was never intended for use in the physical literacy scale. All questions were originally developed and intended for use with persons aged 18–75 years, with sound reliability and validity (Australian Institute of Health and Welfare, 2003; Brown et al., 2008).

Sport motivation scale (SMS) (psychological domain)

Due to its relatively wide-scale adoption (Clancy et al., 2016) we used the SMS (Pelletier et al., 1995) to assess numerous elements of the psychological domain. The SMS includes 28 questions that assess seven types of motivation (to know, to accomplish, stimulation, identified regulation, introjected regulation, external regulation and amotivation), with four items per subscale. In response to the string "Why do you practice your chosen form of physical activity?" participants respond on

a 7-point-Likert scale ranging 1 “*does not correspond at all*” to 7, “*corresponds exactly*”. The SMS has strong indices of validity and reliability within a young adult population (Cronbach alpha, 0.75) (Pelletier et al., 1995), and an older adult population (Cronbach alpha range 0.72–0.87) (Hodge et al., 2008).

Social motivational orientations scale for sport (SMOSS) (social domain)

The SMOSS (Allen, 2003, 2005) was chosen to assess the social domain that contributes to physical literacy. The SMOSS includes 15 items: seven items assess “perceptions of belonging”, four assess “social status”, and four assessed “social recognition”. In response to the stem “I feel things have gone well in my activity when ...” participants respond to each item based on a 5-point Likert scale ranging from 1 “*strongly disagree*” to 5 “*strongly agree*”, a sample item is “I am a part of the ‘in’ crowd”. The reliability of the scale has been examined in a middle-aged sample (29–77 years of age) with acceptable coefficient alphas reported (0.81–0.83) (Hodge et al., 2008).

Self-efficacy in exercise scale (SEE) (psychological domain)

We used the SEE (Resnick & Jenkins, 2000) to assess self-efficacy /confidence towards exercise behaviours (psychological domain of physical literacy). In response to the question “How certain are you right now that you could exercise three times per week for 20 minutes if”, participants are presented with a series of scenarios. A sample item would be “You felt tired”. Participants respond on an 11-point-Likert scale (0 = *Not confident*, 10 = *Very confident*). The 9-item scale has data supporting its predictive validity and internal consistency (alpha = 0.92) in older adults (65+ years) ⁽⁴⁴⁾ with a comparable Cronbach alpha (0.85) found in a middle age sample (18–68 years) of recreational runners (Plateau et al., 2022).

Richards physical self-concept scale (RPSC) (physical domain)

RPSC (Richards, 1987, 1988) is a 35-item instrument designed to measure physical self-concept which we used to assess the physical domain of physical literacy. The instrument asks participants to respond, “how much like them” each statement is (sample item is “Physically I have good coordination”). Participants respond based on an 8-point Likert scale (1 = *Definitely false*, 8 = *Definitely true*). The RPSC has sound psychometric properties in samples 8–80 years with coefficient alphas for all subscales ranging from 0.79 to 0.93 (Marsh & Cheng, 2012; Marsh et al., 1994).

Procedure

After approval from the Human Research Ethics Committee (HREC-3402) participant recruitment commenced. Using a quantitative, cross-sectional design, participants completed the series of questionnaires outlined above. To gain the purposive adult sample, we implemented the following four recruitment strategies. We advertised the survey through a variety of social media platforms including Facebook, Instagram, Twitter and LinkedIn. After monitoring the initial stage of recruitment, specific strategies were applied to target particular populations. To engage with younger participants, the universities

research participation system was used to recruit undergraduate psychology students. To engage older participants (aged 65–75 years), the survey was advertised on a crowd sourcing platform (Prolific, 2014). Finally, to recruit participants routinely engaging in physical activity, a targeted recruitment email was sent to members of a public gym/fitness studio based on the university campus. All individuals voluntarily responded to the recruitment advert. After following a link to the survey hosted on Qualtrics.com, all individuals were provided with information relating to the study and a consent form. Before completing the survey, those interested in participating acknowledged that they fit the inclusion criteria and then provide informed consent. The survey could be completed at a time of convenience, taking approximately 10–20 minutes. There was no time constraint imposed, and individuals had the ability to move back and forth through the survey as desired. Eligible undergraduate students were offered course credit. Participants recruited through crowdsourcing were paid at an hourly rate of approximately AUD \$13.75. All other participants were offered the chance to go in the draw to win one of three \$50 vouchers.

Data analysis

Cleaning/preparing data

After data collection was complete, we transferred all data from Qualtrics.com into SPSS version 27. Within SPSS, all data was cleaned and transformed as per each measure’s respective manual; this includes the calculation of total physical activity as measured in the AAS. Using the select cases feature in SPSS we randomly divided the data sets for the EFA (approximately 60%) and subsequent CFA (approximately 40%). The EFA data set included 57.4% ($n = 592$) of participants, and the CFA data set included the remaining participants ($n = 439$). EFA and CFA data sets were comparable on demographic details pertaining to age, gender and physical activity, as indicated by non-significant independent sample t-tests. Once a clean data set was established, all subsequent data analysis occurred in R studio using the “Psych” package (RStudio, 2022). After initial assumption testing, we conducted EFA and CFA.

EFA

Model creation and progression was based on eigenvalues and scree plot analysis. Using eigenvalues greater than 1, the proposed number of factors was 11, but analysis of the scree plot suggested that a six-factor solution would explain the most variance. As such, model simplification and item reduction commenced with an 11-factor structure and continued to be reduced on a statistical and theoretical basis. The analysis was used to reduce the number of factors, and the number of items to be included in the final measure. All scale types were Likert’s and as such ordinal data. We acknowledge that such data may best be examined through polychoric correlations (Choi et al., 2010), however, given all the original scales have been measured and utilised on a continuous scale, we determined at this early stage it was best to proceed with the assumption of continuous data. Nevertheless, we did check our final model, using a polychoric correlation matrix, and found the model to be comparable.

In acknowledging the interactive nature of physical literacy constructs, we chose an oblique rotation “Promax”. We based our determination of significant factor loadings on Comrey and Lee (1992) recommendations, >0.71 = “excellent”, >0.63 = “very good”, >0.55 = “good”, >0.45 = “fair”, <0.30 = “poor”. In terms of statistical assumptions and testing, we recorded which items failed to load at/or above 0.45, which items continued to load together, and which loadings were/were not theoretically important. Data reduction strategies based on theoretical assumptions were guided by the lead researcher’s understanding of physical literacy, including the use of the Australian physical literacy framework. It is important to note that given the aim of the study was to create a measure of adult physical literacy, original scales and associated sub scales were viewed as a useful tool but were not essential in the final physical literacy measure. The final scale was developed to represent the domains in the context of physical literacy and a subsequent holistic physical literacy measure.

Item reduction phases

Phase 1: With the aim of creating a comprehensive measure whereby a total physical literacy score could be calculated; theoretical understanding and application drove item reduction. As a by-product of study design, factor loadings were representative of the original instruments’ factor structures, including their associated sub scales. As such, we were able to consider which original sub factors were and were not crucial to differentiating individual levels of physical literacy. For example, sub scales (e.g., amotivation) that represent the inverse of the core element (e.g., motivation) were considered for removal.

Phase 2: The next aim of our analysis was to reduce the number of items per factor. While this aspect was largely driven again by theoretical importance, we also utilised statistical information. It was at this stage we began to use CFA techniques to help our conceptualisation of our model and check data representation. Specifically, we focused on ensuring the overall fit of the model did not reduce as items were removed. This phase of item reduction considered each factor separately, commencing with the factor with the highest variance to the factor with the lowest variance.

Phase 3: With the aims of creating a time efficient measure that effectively captured the core elements of physical literacy with limited redundancies, we reduced the number of items relating to motivation and perceived strength. For the motivation items, in maintaining the subscales of the original SMS (to know, accomplish and experience), we identified which items were key to addressing each subscale while also being applicable to adults across all activity types.

CFA techniques

In the final stages of EFA model analysis, we also utilised CFA techniques. In doing so we were able to ensure the removal of items did not significantly degrade the quality of the model and subsequent measure. Findings of the CFA were based on recommendations summarized by Boateng et al. (2018)

a significant Chi square test of exact fit, a Root Mean Square Error of Approximation (RMSEA) ≤ 0.06 and the Tucker Lewis Index (TLI) ≥ 0.95 . To further refine our model as a measure of adult physical literacy, a higher order factor analysis was conducted. The higher order factor analysis ran the original factor analysis/model before identifying how the identified factors load onto a higher order latent variable, labelled “physical literacy”.

Validity and reliability analyses

We assessed validity and reliability on the overall sample. Authors AN, AF and RK assessed the face validity of the measure to assess its acceptability as a holistic measure of physical literacy. In addition to this, LB was used as an external member of the team to obtain an objective view of the measure. Brought in at the “completion” of scale creation and thus blinded to our methodologies, LB was able to provide a direct overview of the physical literacy measure and provide comments on its applicability as a measure of adult physical literacy. We assessed concurrent validity via the assessment of convergent and divergent validity as specified within the Fornell and Larcker method (Fornell & Larcker, 1981), using average variance extracted (AVE) values. To further assess the applicability of the scale, and gain a measure of predictive validity, we conducted correlation analysis to examine the relationship between total physical literacy and physical activity. Finally, when assessing internal reliability (consistency), we calculated Cronbach’s alpha for each of the factors and the overall physical literacy measure. To account for potential bias relating to the number of items in our scale, split half and Guttman reliability estimates were also calculated for the total scale, with all possible split combinations assessed.

Results

Participants

After data cleaning and preparation, 149 participants were removed from the data set. We removed participants for reasons including not meeting the age requirements, or failing to complete the first survey component, making their data unusable. Consequently, the data set appropriate for analysis was composed of 1031 participants, mean age = 37.21 (SD = 18.71).

EFA

Prior to analysis, we removed 20 items (4 subscales) from the RPSC scale as they were not related to the perceived physical competency domain this measure was intended to assess, an approach that Ryom et al. (2022) outlines may be required to subjectively assess the physical domain. Due to univariate normality concerns we decided to use principal axis analysis. In testing if our data was appropriate for factor analysis we conducted and analysed the Kaiser-Meyer-Olkin (KMO), Bartlett’s Test of Sphericity and Squared Multiple Correlation (SMC). The KMO (0.94), Bartlett’s Test of Sphericity (8010.2 (71), $p < .001$) and the SMC matrix showed that the majority of items were appropriately correlated, however, based on SMC scores we

removed item "AAS 3"; as it did not have a communality score above 0.3. We also removed items "SMOSS 11" and "RPSC 25" from the analysis as communality scores were above 0.8. After the deletion of the three variables, we proceeded with the EFA. The initial number of items included in the EFA was 69, the final model consists of 23 items. The following paragraphs will briefly explain the reasoning for item removal and as such subsequent item reduction.

The first method of reduction was based on statistical analysis and interpretation of the 11-factor structure. To aid in interpretation and further analysis, the 11 factors were labelled "motivation", "amotivation", "external regulation", "introjected regulation", "confidence", "social", "social status", "coordination", "strength", "action" and "knowledge". After examining the rotated factor structure, we deleted items "AAS 4", "SMS 6", "SMS 7", "SMS 10", "SMS 24" and "SMOSS 1", as they did not load at 0.45 or above on any of the proposed 11 factors. Significant cross loadings (≥ 0.3) were also present for items "SMS 22", "SMOSS 9", "SMOSS 10", "SMOSS 13" and "RPSC 26", resulting in the removal of these items. At this stage, we retained 58 items in the data set.

Phase 1: The first phase of item reduction, driven by considerations of theoretical alignment and applicability, resulted in the removal of $n = 17$ items. We deleted items ($n = 9$) that loaded onto the factors "amotivation", "external regulation" and "introjected regulation". Likewise, we deleted four items from the "social status" factor. Finally, we deleted four items from the "action" subscale. After deleting the items relating to the previously identified subscales, 41 items remained, and based on eigenvalues and scree plots analysis the number of appropriate factors was six. After phase 1 item reduction, the six factors remaining were "motivation", "confidence", "social", "coordination", "strength" and "knowledge". At this stage of analysis, model fit scores were; $\chi^2 (589) = 1913.740$, $p < 0.001$; TLI = 0.891; RMSEA = 0.062 (95% CI: 0.058, 0.065).

Phase 2: Starting with the motivation factor, each remaining sub domain (To Know, Accomplish, Experience) of the original

scale (SMS) was reduced to two items ($n = 6$ deleted). The items retained in the model were better aligned with physical literacy. The confidence factor, originally measured by SES, was reduced based on having one statement covering the overarching aspect of the items, (e.g., affective/mood, $n = 4$ deleted). Likewise, the social factor originally measured by the SMOSS, was reduced by two items, as they were effectively captured in other responses (fun, friendship). The two perceived physical competence factors of "perceived coordination" and "perceived strength" as measured in the RPSC were reduced by removing the item which could be viewed as semantically different and deviated from the physical literacy definition ($n = 2$). At this stage of item reduction, no changes were made to the "knowledge" factor. Current model fit scores for the 27-item scale are, $\chi^2 (204) = 467.197$, $p < 0.001$; TLI = 0.948; RMSEA = 0.046 (95% CI: 0.040, 0.053).

Phase 3: To ensure the remaining items represented various elements of the psychological domain and physical literacy more broadly, each sub domain of the SMS was reduced to include only the most salient item, and items "SMS 4, 23, 8, 20, 1 and 25" were removed. Consequently, we retained five items for the motivation construct, leaving 24 items in the proposed measure, with current model fit scores, $\chi^2 (147) = 309.601$, $p < 0.001$; TLI = 0.957; RMSEA = 0.043 (95% CI: 0.035, 0.051). We then reduced the number of items used to measure perceived strength. We removed "RPSC 31" as it was closely linked to "RPSC 8" with the concept of both items measurable in one. The 23-item measure was the best representation of the data, $\chi^2 (130) = 254.770$, $p < 0.001$; TLI = 0.965; RMSEA = 0.040 (95% CI: 0.031, 0.049), and as such was retained. We would like to highlight that item "AAS 5" dropped below the *a priori* factor loading cut off point (0.44) during the final modelling stages (27-item model) however, due to the exploratory nature and the small magnitude of the violation, we decided to retain the item for the CFA to examine its value and influence within a different data set. Furthermore, the removal of

Table 1. Factor loadings for the Physical Literacy in Adults Scale (PLAS) from the exploratory factor analysis.

PLAS item number	Original item	Motivation	Social	Confidence	Coordination	Strength	Knowledge	h2	u2	com
1	SMS2	0.705	0.020	0.030	0.009	-0.011	-0.039	0.528	0.472	1.012
2	SMS11	0.765	-0.034	0.000	-0.022	-0.003	0.042	0.548	0.452	1.012
3	SMS12	0.845	-0.039	-0.043	-0.043	-0.018	0.015	0.618	0.382	1.016
4	SMS13	0.829	0.061	-0.025	0.047	-0.057	-0.032	0.723	0.277	1.032
5	SMS27	0.769	0.021	-0.015	0.014	0.032	-0.047	0.630	0.370	1.014
6	SMOSS2	0.099	0.746	-0.013	-0.033	0.032	0.018	0.643	0.357	1.045
7	SMOSS6	0.014	0.818	0.027	0.010	0.021	-0.002	0.698	0.302	1.004
8	SMOSS7	-0.044	0.907	0.020	0.016	0.037	-0.024	0.808	0.192	1.011
9	SMOSS15	0.030	0.758	0.041	-0.010	-0.036	0.035	0.590	0.410	1.018
10	SEE1	0.165	-0.073	0.495	0.041	0.138	-0.018	0.439	0.561	1.458
11	SEE3	0.066	0.014	0.678	-0.052	-0.030	-0.022	0.465	0.535	1.038
12	SEE5	-0.067	-0.103	0.741	0.009	-0.061	-0.016	0.498	0.502	1.070
13	SEE6	-0.081	0.042	0.817	0.005	-0.001	0.042	0.629	0.371	1.031
14	SEE7	-0.010	0.079	0.861	-0.005	-0.023	0.027	0.732	0.268	1.021
15	RPSC7	-0.021	0.042	0.019	0.868	-0.015	-0.011	0.752	0.248	1.008
16	RPSC30	0.045	-0.005	0.015	0.728	0.101	0.024	0.666	0.334	1.049
17	RPSC35	0.008	-0.031	-0.034	0.922	-0.031	0.003	0.795	0.205	1.007
18	RPSC8	0.030	-0.049	0.000	-0.070	0.806	-0.001	0.595	0.405	1.025
19	RPSC14	-0.050	0.080	-0.049	0.031	0.918	-0.014	0.839	0.161	1.030
20	RPSC19	-0.032	-0.012	0.031	0.027	0.718	-0.003	0.536	0.464	1.011
21	AAS 1	0.016	-0.023	0.010	-0.016	0.746	0.746	0.567	0.433	1.018
22	AAS 2	-0.074	0.023	0.045	0.019	-0.072	0.797	0.636	0.364	1.043
23	AAS 5	0.097	-0.033	-0.044	-0.005	0.016	0.444	0.206	0.794	1.130

Table 2. Factor loadings for the Physical Literacy in Adults Scale (PLAS) confirmatory factor analysis.

PLAS item number	Original item	Motivation	Social	Confidence	Coordination	Strength	Knowledge	h2	u2	com
1	SMS2	0.692	0.095	0.041	-0.033	0.002	0.011	0.544	0.456	1.050
2	SMS11	0.765	0.010	-0.039	-0.063	0.040	-0.035	0.561	0.439	1.029
3	SMS12	0.893	-0.031	-0.110	0.012	-0.056	0.010	0.667	0.333	1.041
4	SMS13	0.829	-0.068	0.031	0.089	-0.023	-0.016	0.724	0.276	1.042
5	SMS27	0.723	0.021	0.122	-0.031	0.037	-0.009	0.640	0.360	1.068
6	SMOSS2	0.088	0.587	-0.035	-0.035	0.114	0.001	0.449	0.551	1.136
7	SMOSS6	0.019	0.687	0.044	0.095	-0.080	-0.029	0.483	0.517	1.080
8	SMOSS7	-0.129	0.784	-0.036	0.005	-0.060	-0.008	0.539	0.461	1.071
9	SMOSS15	0.051	0.805	-0.040	0.036	-0.042	-0.009	0.665	0.335	1.023
10	SEE1	-0.022	0.849	0.033	-0.086	0.070	0.041	0.724	0.276	1.044
11	SEE3	0.017	-0.026	0.866	-0.112	0.109	-0.019	0.738	0.262	1.069
12	SEE5	-0.009	0.003	0.864	-0.062	0.037	-0.006	0.718	0.282	1.014
13	SEE6	-0.024	-0.009	0.888	0.046	-0.025	-0.018	0.791	0.209	1.009
14	SEE7	0.021	0.035	0.695	0.148	-0.161	0.067	0.557	0.443	1.230
15	RPSC7	-0.012	-0.037	-0.027	0.903	0.017	0.012	0.796	0.204	1.006
16	RPSC30	0.069	-0.027	0.003	0.739	0.130	0.008	0.704	0.296	1.083
17	RPSC35	-0.007	0.025	-0.014	0.903	-0.008	-0.011	0.808	0.192	1.003
18	RPSC8	0.047	-0.018	0.006	0.005	0.796	-0.015	0.664	0.336	1.009
19	RPSC14	0.010	-0.038	0.006	0.058	0.904	-0.004	0.857	0.143	1.012
20	RPSC19	-0.098	0.106	0.028	0.021	0.780	0.001	0.649	0.351	1.073
21	AAS 1	-0.025	0.028	0.033	0.052	-0.019	0.795	0.630	0.370	1.018
22	AAS 2	-0.014	-0.007	-0.046	-0.048	-0.004	0.772	0.611	0.389	1.016
23	AAS 5	0.068	-0.008	-0.021	-0.023	0.055	0.458	0.212	0.788	1.084

item “AAS 5” did not improve the fit of the model. The final model matrix is provided in [Table 1](#).

CFA

In assessing the goodness of fit for the proposed model identified through EFA we ran the final factor model with a new, previously unused sample ($n = 439$) see [Table 2](#). The CFA analysis showed acceptable fit to the new data set, $\chi^2(130) = 252.005$, $p < 0.001$; TLI = 0.957; RMSEA = 0.046 (95% CI: 0.036, 0.056). Results of the higher order factor analysis as seen in [Figure 1](#), show our model was effective at mapping onto the higher order latent variable (“physical literacy”), with correlations ranging from 0.38 to 0.71. Of note, the knowledge factor did not load onto the higher order variable. To test the importance of knowledge in the model, we removed the associated questions and reran the CFA with a five-factor solution. The five-factor model was not a better fit to the data ($\chi^2(100) = 215.296$, $p < 0.001$; TLI = 0.958; RMSEA = 0.051 (95% CI: 0.04, 0.063). Likewise, the removal of the knowledge factor did not change any of the higher order factor correlations. As such, in being consistent with theory which emphasizes cognitive contributions to physical literacy, we decided to retain the six-factor solution, which included the knowledge element. We accepted that the 23-item six factor model identified was an appropriate measure of physical literacy and its domains, with the domains of social (social factor), psychological (motivation and confidence factors), physical (strength and coordination factors) and cognitive (knowledge factor) all addressed. Therefore, six factors were included in the final Physical Literacy in Adults Scale (PLAS) ([Appendix Table A1](#)).

Validity and reliability analyses

We assessed reliability and validity in the overall sample ([Table 3](#)).

Validity

Due to the design of this study, we were satisfied that the new measure would have acceptable face validity, with the final items being accepted as fitting the associated factor and the holistic physical literacy category. Additionally, the external expert (LB), interpreted the model as intended, identifying two additional elements not originally considered for SEE items 6 and 7. However, both the original (confidence) and new suggestions (reasoning and strategy and planning) were related to the multidimensional aspect of the items, both views were appropriate and incorporated into Supplementary Table S2.

In our analysis, AVE scores were at or above 0.5, suggesting convergent validity. Additionally, all identified factors loaded onto the same factor structure presented within original scales. All squared AVE scores were greater than factor correlation loadings, and likewise the lack of cross loading between items also suggests items only loaded onto their single, respective domain indicating divergent validity. Our analysis identified a weak positive ($r = 0.331$, $p = < 0.001$) association between the holistic score on the PLAS and total physical activity: thus, providing initial evidence for the predictive validity of the scale, by clearly associating total physical literacy scores with physical activity behaviours.

Internal reliability

Cronbach Alpha's scores ranged from 0.70 to 0.90, with all but one domain (knowledge) being at or above 0.85. The Cronbach alpha for the overall PLAS was 0.87. Split half and Guttman reliability estimates can be viewed in [Table 4](#) and demonstrates that in general, the scale has good internal consistency.

Discussion

This study aimed to address the lack of a widely applicable, holistic measurement of physical literacy in an adult population, by developing and validating a new physical literacy

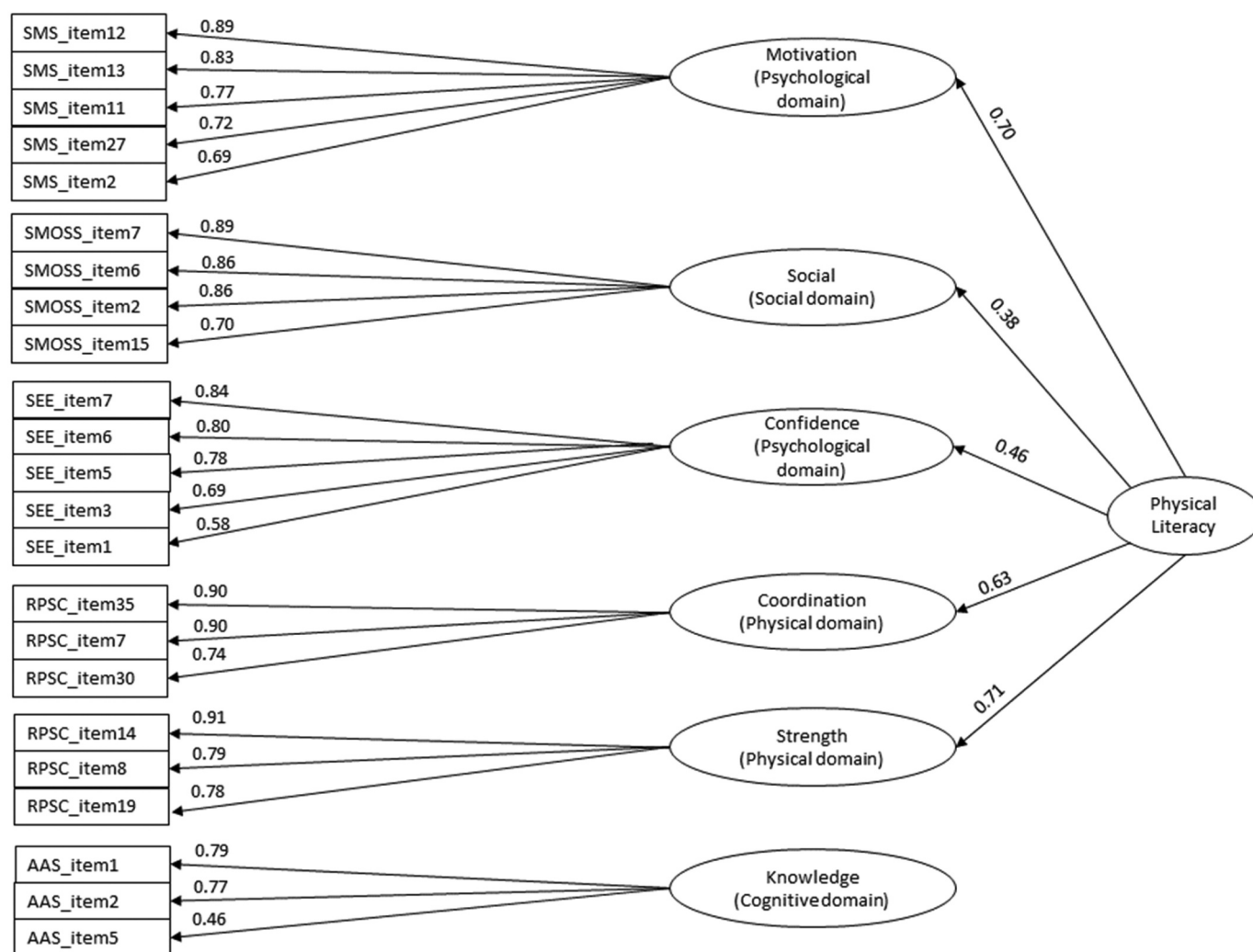


Figure 1. Results of higher order factor analysis. Note: SMS = Sports motivation scale, SMOSS = Social motivation orientation in sports scale, SEE = Self efficacy for exercise scale, RPSC = Richards physical self-concept scale, AAS = Active Australia survey.

Table 3. Correlation, validity and reliability analysis for the entire sample.

Factors	Motivation	Social	Confidence	Coordination	Strength	Knowledge
Motivation	1.000					
Social	0.514	1.000				
Confidence	0.373	0.034	1.000			
Coordination	0.390	0.277	0.261	1.000		
Strength	0.423	0.181	0.427	0.568	1.000	
Knowledge	0.009	-0.007	-0.019	0.052	0.006	1.000
Variance explained	0.136	0.120	0.118	0.096	0.092	0.061
Cronbach alpha	0.880	0.900	0.850	0.890	0.860	0.700
AVE	0.612	0.672	0.545	0.724	0.678	0.468
AVE squared	0.782	0.820	0.739	0.851	0.823	0.684

AVE= average variance explained.

Table 4. Reliability estimates for the 23-item PLAS.

Reliability estimate	Value
Cronbach alpha	0.87
Maximum split half	0.94
Average split half	0.86
Minimum split half	0.51
Guttman lambda 6	0.92
Guttman lambda 2	0.89

measurement tool for adults. In constructing the proposed measure, we adopted tools previously validated in an adult population, and a robust methodology, resulting in a scale validated to assess adult physical literacy that is not reliant on individual domain measures or child/youth assessment tools. The current study designed the PLAS, a single psychometric measure of physical literacy applicable to adults aged 18–75. The comprehensive 23-item measure includes six factors of physical literacy. The factors align with the four domains

outlined in the definition of physical literacy provided by Keegan et al. (2019), providing a holistic physical literacy outcome with sound reliability and validity.

We undertook this study because in previous research on adult physical literacy measurement, child/adolescent scales were used, or the validity and reliability of the respective domain measures *when combined* was not always assessed (Dlugonski et al., 2022). Although holistic measures of physical literacy have been developed and validated for use with children and adolescents, such measures should not be transferred to an adult population (Dlugonski et al., 2022). Adult physical activity and physical literacy are likely to be different to the child/youth populations (Jones et al., 2018; Petrusevski et al., 2022; Westerbeek & Eime, 2021; Whitehead, 2013b). For example, in an adult population, the desire (or not) to live a healthy and fulfilling life is self-driven and is not facilitated through school-based physical education programs. As such, the infrastructure, settings, and type of activity/learning vary greatly (Jenkin et al., 2018; Westerbeek & Eime, 2021), which may render the application of child measures in an adult population inappropriate. Beyond the transfer of child/adolescent scales, current attempts to holistically measure adult physical literacy also present psychometric issues (Boldovskaia et al., 2023). Such limitations make the interpretation of previous results challenging. By going beyond assessing individual domains and catering for the need to develop a single holistic measure of physical literacy applicable to the adult population, the PLAS constitutes an appropriate and validated measurement of adult physical literacy, offering new opportunities and advancement for researchers in this topic.

The PLAS is a six-factor model which covers current theoretical domains of physical literacy (physical, psychological, cognitive, social). By covering all domains and providing a holistic score, the PLAS is the first measure to do so in an adult population. Nonetheless, an important finding in this study relates to the cognitive domain (knowledge factor of the PLAS). Specifically, while the knowledge factor has good internal consistency and importance to our model, its contribution to physical literacy is unclear (see Figure 1). Issues pertaining to the measurement of the cognitive domain of physical literacy are not new (Dlugonski et al., 2022; Ryom et al., 2022). In many cases the cognitive domain is overlooked or similar to the current study only accounts for knowledge in the form of awareness of health messaging (Dudley & Cairney, 2022; Ryom et al., 2022). While the assessment of the cognitive domain based on awareness has been used in the CAPL (Longmuir, 2013; Longmuir et al., 2015) and acknowledged as a well-established and validated physical literacy assessment for children (Barnett et al., 2023; Shearer et al., 2021), we may not capture the full scope of the cognitive domain nor the central interactive components (Cairney, Dudley, et al., 2019; Dudley & Cairney, 2022; Ryom et al., 2022). While we have decided to retain questions pertaining to knowledge in our measure to remain consistent with theoretical understanding of physical literacy, future advancements of the PLAS and physical literacy, must look to include numerous elements of

the cognitive domain (e.g., purpose and reasoning) in its measurement to truly evaluate the importance and role of this domain in physical literacy.

Strengths and limitations

The comprehensive measure of physical literacy, created within this study, poses avenues for theoretical advancement, however scale applicability and study generalisability must also be considered. First, the PLAS is well-placed as a multidimensional measure of physical literacy, which not only covered the core elements (motivation, confidence, content knowledge, strength, coordination, balance and relationships) but also addresses an additional 7 elements (see Supplementary file Table S2). Items in the PLAS emphasise the integrative nature of physical literacy, with selected items offering cross-domain and cross-element application. Nonetheless, while the PLAS does cover 14/30 of the elements and all four domains, it does not cover every suggested facet/element of physical literacy proposed by Keegan et al. (2019). For example, the individual elements of “speed”, “connection to place”, “ethics” and “risks” are not specifically assessed in the PLAS. Researchers who are seeking an in depth understanding of specific competencies not currently assessed (e.g., speed) may still need to use a specific measure (e.g., 40 m Sprint (Fitzsimons et al., 1993)) to assess such facets. We note here, however, that this approach is not usually recommended as it moves away from the holistic nature of physical literacy and reverts to specific skill competencies.

Second, because the sample was purposively recruited and not randomly selected, issues surrounding generalisability need to be considered. During study design and participant recruitment, we explicitly considered factors such as age and level-of-physical activity. We wanted to ensure we captured the full range of ages, lifestyles/occupations, and physical activity levels within the current sample, as we would expect these to be related to physical literacy (Edwards et al., 2017; Jones et al., 2018; Westerbeek & Eime, 2021). We were able to recruit a large and diverse sample, covering an array of demographic factors such as educational levels and employment statuses of adults aged 18–75 (see Supplementary file Table S1). Nevertheless, we did not specifically target marginalised groups, for example based on ethnicity, socioeconomic status, non-English speaking status, or disability and/or chronic health status. Such factors have also been linked to different physical literacy interpretations and experiences (Edwards et al., 2017; Pushkarenko et al., 2021; Whitehead, 2013a).

We must also consider the influence of the guiding physical literacy definition on scale and study applicability. We decided to conduct this study using the Australian framework for physical literacy, which was based on its inclusive nature: catering for all ages, abilities and backgrounds (Keegan et al., 2019). While the Australian framework is inclusive, applying it to individuals living outside of Australia (a minority of the sample) may raise issues of generalisability. Additional considerations should also be given to the inclusion of the social domain in the Keegan et al. (2019) definition, which recognises important

social aspects, linked with helping adults lead healthy lives (Jenkin et al., 2018; Wolman & Fraser-Thomas, 2017). Although not encompassed in global definitions, we acknowledge a trend to include aspects of a social domain in global physical literacy definitions, particularly those addressing the adult population (Jones et al., 2018; Petrusevski et al., 2022). Nevertheless, while the Australian definition is considered comprehensive and inclusive, (covering all aspects of other global definitions) by primarily aligning the PLAS to the Australian definition, the scale risks being incompatible with other schools of thoughts/frameworks/definitions which may require further evaluation as to the suitability of the PLAS.

Future directions and conclusions

The PLAS is offered as a valid measure that is suitable for use in future research projects examining adult physical literacy. As we continue to assess the suitability of the PLAS, we must address the previously highlighted demographic considerations. As such, future research should ascertain the scale's validity in additional international samples which are inclusive of culturally and linguistically diverse populations. Future research should also assess the scale's usefulness with various definitions in the ever-evolving landscape of physical literacy research; allowing us to determine the feasibility of the PLAS in a global understanding of adult physical literacy. Furthermore, the introduction of additional questions addressing the cognitive domain, along with other "missing" elements may further develop our understanding of adult physical literacy. The PLAS is a purpose-built holistic measure of physical literacy which provides an avenue through which cross-sectional research can continue to develop. We can now begin to address the effectiveness of physical literacy interventions and the associated outcome behaviours such as physical activity and/or health outcomes in an adult population. Future research should use the PLAS to begin investigations of physical literacy as a lifelong journey.

In conclusion, the present study has provided initial validation of the PLAS. The devised scale provides a comprehensive measure of adult physical literacy, providing a valid and reliable way to assess adult physical literacy. Although issues surrounding generalisability need to be addressed, the PLAS provides a basis for ongoing research into this under researched population, providing an important first step in understanding physical literacy as a lifelong journey.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

The author(s) reported there is no funding associated with the work featured in this article.

ORCID

Annaleise Naylor  <http://orcid.org/0000-0002-1689-725X>

Data availability statement

Raw data is not included in this manuscript, however it may be made available by request to the first author.

Ethics approval statement

All aspects of the study were approved by the Human Research Ethics Committee at the University of Canberra. No ethical issues were reported in this study.

Informed consent

Prior to participation, participants provided informed consent as detailed in the methodology section (page 11) and as approved by the Ethics committee.

References

- Allen, J. B. (2003). Social motivation in youth sport. *Journal of Sport & Exercise Psychology*, 25(4), 551–567. <https://doi.org/10.1123/jsep.25.4.551>
- Allen, J. B. (2005). Measuring social motivational orientations in sport: An examination of the construct validity of the SMOSS. *International Journal of Sport & Exercise Psychology*, 3(2), 147–161. <https://doi.org/10.1080/1612197X.2005.9671764>
- Almond, L. (2013). *What is the relevance of physical literacy for adults?* ICSSPE Bulletin.
- Australian Institute of Health and Welfare. (2003). *The active Australia survey: A guide and manual for implementation, analysis and reporting*.
- Barnett, L. M., Jerebine, A., Keegan, R., Watson-Mackie, K., Arundell, L., Ridgers, N. D., Salmon, J., & Dudley, D. (2023). Validity, reliability, and feasibility of physical literacy assessments designed for school children: A systematic review. *Sports Medicine*, 53(10), 1905–1929. <https://doi.org/10.1007/s40279-023-01867-4>
- Boateng, G. O., Neilands, T. B., Frongillo, E. A., Melgar-Quinonez, H. R., & Young, S. L. (2018). Best practices for developing and validating scales for health, social, and behavioral research: A primer. *Frontiers in Public Health*, 6, 149. <https://doi.org/10.3389/fpubh.2018.00149>
- Boldovskaia, A., Dias, N. M. G., Silva, M. N., Carraca, E. V., & Nikou, S. (2023). Physical literacy assessment in adults: A systematic review. *PLOS ONE*, 18(7), e0288541. <https://doi.org/10.1371/journal.pone.0288541>
- Brown, W. J., Burton, N. W., Marshall, A. L., & Miller, Y. D. (2008). Reliability and validity of a modified self-administered version of the active Australia physical activity survey in a sample of mid-age women. *Australian and New Zealand Journal of Public Health*, 32(6), 535–541. <https://doi.org/10.1111/j.1753-6405.2008.00305.x>
- Cairney, J., Clark, H., Dudley, D., & Kriellaars, D. (2019). Physical literacy in children and youth—A construct validation study. *Journal of Teaching in Physical Education*, 38(2), 84–90. <https://doi.org/10.1123/jtpe.2018-0270>
- Cairney, J., Dudley, D., Kwan, M., Bulten, R., & Kriellaars, D. (2019). Physical literacy, physical activity and health: Toward an evidence-informed conceptual model. *Sports Medicine*, 49(3), 371–383. <https://doi.org/10.1007/s40279-019-01063-3>
- Choi, J., Peters, M., & Mueller, R. O. (2010). Correlational analysis of ordinal data: From Pearson's r to Bayesian polychoric correlation. *Asia Pacific Education Review*, 11(4), 459–466. <https://doi.org/10.1007/s12564-010-9096-y>
- Clancy, R. B., Herring, M. P., MacIntyre, T. E., & Campbell, M. J. (2016). A review of competitive sport motivation research. *Psychology of Sport & Exercise*, 27, 232–242. <https://doi.org/10.1016/j.psychsport.2016.09.003>
- Comrey, A. L., & Lee, H. B. (1992). *A first course in factor analysis* (2nd ed.). Psychology press.
- Dlugonski, D., Gadd, N., McKay, C., Kleis, R. R., & Hoch, J. M. (2022). Physical literacy and physical activity across the life span: A systematic review. *Translational Journal of the American College of Sports Medicine*, 7(3). <https://doi.org/10.1249/TJX.0000000000000201>

- Dudley, D., & Cairney, J. (2022). How the lack of content validity in the Canadian assessment of physical literacy is undermining quality physical education. *Journal of Teaching in Physical Education*, 1(aop), 1–8.
- Edwards, L. C., Bryant, A. S., Keegan, R. J., Morgan, K., & Jones, A. M. (2017). Definitions, foundations and associations of physical literacy: A systematic review. *Sports Medicine*, 47(1), 113–126. <https://doi.org/10.1007/s40279-016-0560-7>
- Elsborg, P., Heinze, C., Melby, P. S., Nielsen, G., Bentsen, P., & Ryom, K. (2021). Associations between previous sport and exercise experience and physical literacy elements among physically inactive danes. *BMC Public Health*, 21(1). <https://doi.org/10.1186/s12889-021-11299-2>
- Fitzsimons, M., Dawson, B., Ward, D., & Wilkinson, A. (1993). Cycling and running tests of repeated sprint ability. *Australian Journal of Science and Medicine in Sport*, 25(1), 82.
- Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. *Journal of Marketing Research*, 18(1), 39–50. <https://doi.org/10.1177/002224378101800104>
- Gandrieau, J., Schnitzler, C., Cairney, J., Keegan, R., Roberts, W. M., Barnett, L. M., Bentsen, P., Dudley, D. A., Raymond Sum, K. W., Venetsanou, F., Button, C., Turcotte, S., Berrigan, F., Cloes, M., Rudd, J. R., Riga, V., Mouton, A., Vašíčková, J., ... Scheuer, C. (2023). Development of ELIP to assess physical literacy for emerging adults: A methodological and epistemological challenge. *Research Quarterly for Exercise & Sport*, 94(4), 1169–1182. <https://doi.org/10.1080/02701367.2022.2125927>
- Green, N. R., Roberts, W. M., Sheehan, D., & Keegan, R. J. (2018). Charting physical literacy journeys within physical education settings. *Journal of Teaching in Physical Education*, 37(3), 272–279. <https://doi.org/10.1123/jtpe.2018-0129>
- Hodge, K., Allen, J. B., & Smellie, L. (2008). Motivation in masters sport: Achievement and social goals. *Psychology of Sport & Exercise*, 9(2), 157–176. <https://doi.org/10.1016/j.psychsport.2007.03.002>
- Holler, P., Jaunig, J., Amort, F.-M., Tuttner, S., Hofer-Fischanger, K., Wallner, D., Simi, H., Müller, A., van Poppel, M. N. M., & Moser, O. (2019). Holistic physical exercise training improves physical literacy among physically inactive adults: A pilot intervention study. *BMC Public Health*, 19(1), 1–14. <https://doi.org/10.1186/s12889-019-6719-z>
- Holler, P., Jaunig, J., Moser, O., Tuttner, S., Simi, H., Wallner, D., Amort, F. M., & van Poppel, M. (2021). Primary care and physical literacy: A non-randomized controlled pilot study to combat the high prevalence of physically inactive adults in Austria. *International Journal of Environmental Research and Public Health*, 18(16), 8593. <https://doi.org/10.3390/ijerph18168593>
- International Physical Literacy Association I. (2017). *International physical literacy association: IPLA United Kingdom*. <https://www.physical-literacy.org.uk/>
- Jenkin, C. R., Eime, R. M., Westerbeek, H., & van Uffelen, J. G. (2018). Sport for adults aged 50+ years: Participation benefits and barriers. *Journal of Aging & Physical Activity*, 26(3), 363–371. <https://doi.org/10.1123/japa.2017-0092>
- Jones, G. R., Stathokostas, L., Young, B. W., Wister, A. V., Chau, S., Clark, P., Duggan, M., Mitchell, D., & Nordland, P. (2018). Development of a physical literacy model for older adults—a consensus process by the collaborative working group on physical literacy for older Canadians. *BMC Geriatrics*, 18(1), 13. <https://doi.org/10.1186/s12877-017-0687-x>
- Keegan, R., Barnett, L., Dudley, D. A., Telford, R. D., Lubans, D. R., Bryant, A. S., Roberts, W. M., Morgan, P. J., Schranz, N. K., Weissensteiner, J. R., Vella, S. A., Salmon, J., Ziviani, J., Okely, A. D., Wainwright, N., & Evans, J. R. (2019). Defining physical literacy for application in Australia: A modified delphi method. *Journal of Teaching in Physical Education*, 38(2), 105–118. <https://doi.org/10.1123/jtpe.2018-0264>
- Kleis, R. R., Dlugonski, D., Baker, C. S., Hoch, J. M., & Hoch, M. C. (2022). Examining physical literacy in young adults: Psychometric properties of the PLAYself. *Applied Physiology, Nutrition, and Metabolism*, 47(9), 926–932. <https://doi.org/10.1139/apnm-2022-0062>
- Kwan, M. Y., Graham, J. D., Bedard, C., Bremer, E., Healey, C., & Cairney, J. (2019). Examining the effectiveness of a pilot physical literacy-based intervention targeting first-year university students: The PLUS program. *Sage Open*, 9(2), 2158244019850248. <https://doi.org/10.1177/2158244019850248>
- Kwan, M. Y. W., Graham, J. D., Healey, C., Paolucci, N., & Brown, D. M. (2020). Stopping the drop: Examining the impact of a pilot physical literacy-based intervention program on physical activity behaviours and fitness during the transition into university. *International Journal of Environmental Research and Public Health*, 17(16), 5832. <https://doi.org/10.3390/ijerph17165832>
- Liu, C.-Y., Lin, L.-C., Sheu, J.-J., & Sum, R. K. W. (2022). Psychometric validation of senior perceived physical literacy instrument. *International Journal of Environmental Research and Public Health*, 19(11), 6726. <https://doi.org/10.3390/ijerph19116726>
- Longmuir, P. E. (2013). Understanding the physical literacy journey of children: The Canadian assessment of physical literacy. *ICSSPE Bulletin-Journal of Sport & Exercise Psychology*, 65(12.1), 277–284. <https://www.physical-literacy.org.uk/research/icsspe-bulletin-65/>
- Longmuir, P. E., Boyer, C., Lloyd, M., Yang, Y., Boiarskaia, E., Zhu, W., & Tremblay, M. S. (2015). The Canadian assessment of physical literacy: Methods for children in grades 4 to 6 (8 to 12 years). *BMC Public Health*, 15(1), 767. <https://doi.org/10.1186/s12889-015-2106-6>
- Longmuir, P. E., & Tremblay, M. S. (2016). Top 10 research questions related to physical literacy. *Research Quarterly for Exercise & Sport*, 87(1), 28–35. <https://doi.org/10.1080/02701367.2016.1124671>
- Ma, R.-S., Sum, R. K. W., Hu, Y.-N., & Gao, T.-Y. (2020). Assessing factor structure of the simplified Chinese version of perceived physical literacy instrument for undergraduates in Mainland China. *Journal of Exercise Science & Fitness*, 18(2), 68–73. <https://doi.org/10.1016/j.jesf.2020.01.001>
- Marsh, H. W., & Cheng, J. H. (2012). Physical self-concept. *Measurement in Sport and Exercise Psychology: Human Kinetics*, 215–226.
- Marsh, H. W., Richards, G. E., Johnson, S., Roche, L., & Tremayne, P. (1994). Physical self-description questionnaire: Psychometric properties and a multitrait-multimethod analysis of relations to existing instruments. *Journal of Sport & Exercise Psychology*, 16(3), 270–305. <https://doi.org/10.1123/jsep.16.3.270>
- Martins, J., Onofre, M., Mota, J., Murphy, C., Repond, R.-M., Vost, H., Cremosini, B., Svrdlim, A., Markovic, M., & Dudley, D. (2021). International approaches to the definition, philosophical tenets, and core elements of physical literacy: A scoping review. *Prospects*, 50(1–2), 13–30. <https://doi.org/10.1007/s11125-020-09466-1>
- Ouchi, Y., Rakugi, H., Arai, H., Akishita, M., Ito, H., Toba, K., & Kai, I. (2017). Redefining the elderly as aged 75 years and older: Proposal from the joint committee of Japan gerontological society and the Japan geriatrics society. *Geriatrics & Gerontology International*, 17(7), 1045–1047. <https://doi.org/10.1111/ggi.13118>
- Pelletier, L. G., Tuson, K. M., Fortier, M. S., Vallerand, R. J., Briere, N. M., & Blais, M. R. (1995). Towards a new measure of intrinsic motivation, extrinsic motivation, and amotivation in sports - the sport motivation scale (SMS). *Journal of Sport & Exercise Psychology*, 17(1), 35–53. <https://doi.org/10.1123/jsep.17.1.35>
- Petrusevski, C., Morgan, A., MacDermid, J., Wilson, M., & Richardson, J. (2022). Framing physical literacy for aging adults: An integrative review. *Disability and Rehabilitation*, 44(26), 8149–8160. <https://doi.org/10.1080/09638288.2021.2012841>
- Plateau, C. R., Anthony, J., Clemes, S. A., & Stevinson, C. D. (2022). Prospective study of beginner running groups: Psychological predictors and outcomes of participation. *Behavioral Medicine*, 50(1), 55–62. <https://doi.org/10.1080/08964289.2022.2100865>
- Prolific. (2014). *England*. <https://www.prolific.co/>
- Pushkarenko, K., Causgrove Dunn, J., & Wohlers, B. (2021). Physical literacy and inclusion: A scoping review of the physical literacy literature inclusive of individuals experiencing disability. *Prospects*, 50(1–2), 107–126. <https://doi.org/10.1007/s11125-020-09497-8>
- Resnick, B., & Jenkins, L. S. (2000). Testing the reliability and validity of the self-efficacy for exercise scale. *Nursing Research*, 49(3), 154–159. <https://doi.org/10.1097/00006199-200005000-00007>
- Richards, G. E. (1987). Outdoor education in Australia in relation to the Norman Conquest, a Greek Olive Grove and the external perspective of a Horse's mouth. *Fifth National Outdoor Education Conference*, Perth, Australia.

- Richards, G. E. (1988). *Physical self-concept scale*. Australian Outward Bound Foundation.
- Robinson, L. E., Stodden, D. F., Barnett, L. M., Lopes, V. P., Logan, S. W., Rodrigues, L. P., & D'Hondt, E. (2015). Motor competence and its effect on positive developmental trajectories of health. *Sports Medicine*, 45(9), 1273–1284. <https://doi.org/10.1007/s40279-015-0351-6>
- RStudio. (2022). *Psych: Procedures for psychological, psychometric, and personality research* (Revelle W. ed.). Northwestern University.
- Ryom, K., Hargaard, A.-S., Melby, P. S., Maindal, H. T., Bentsen, P., Ntoumanis, N., Schoeppe, S., Nielsen, G., & Elsborg, P. (2022). Self-reported measurements of physical literacy in adults: A scoping review. *British Medical Journal Open*, 12(9), e058351. <https://doi.org/10.1136/bmjopen-2021-058351>
- Sanderson, W. C., Scherbov, S., & Dowd, J. B. (2015). Faster increases in human life expectancy could lead to slower population aging. *PLOS ONE*, 10(4), e0121922. <https://doi.org/10.1371/journal.pone.0121922>
- Shearer, C., Goss, H. R., Boddy, L. M., Knowles, Z. R., Durden Myers, E. J., & Fowweather, L. (2021). Assessments related to the physical, affective and cognitive domains of physical literacy amongst children aged 7–11.9 years: A systematic review. *Sports Medicine - Open*, 7(1). <https://doi.org/10.1186/s40798-021-00324-8>
- Sum, R. K. W., Ha, A. S. C., Cheng, C. F., Chung, P. K., Yiu, K. T. C., Kuo, C. C., Yu, C. K., & Wang, F. J. (2016). Construction and validation of a perceived physical literacy instrument for physical education teachers. *PLOS ONE*, 11(5), e0155610. <https://doi.org/10.1371/journal.pone.0155610>
- Thermou, A., & Riga, V. (2020). Research review for the presence of physical literacy in the world. *European Journal of Physical Education and Sport Science*, 6(3), 92–113. <https://zenodo.org/doi/10.5281/zenodo.3748021>.
- Westerbeek, H., & Eime, R. (2021). The physical activity and sport participation framework—a policy model toward being physically active across the lifespan. *Frontiers in Sports and Active Living*, 3, 90. <https://doi.org/10.3389/fspor.2021.608593>
- Whitehead, M. (2013a). Definition of physical literacy and clarification of related issues. *ICSSPE Bulletin*, 65(1.2), 29–35. <https://www.physical-literacy.org.uk/research/icsspc-bulletin-65/>
- Whitehead, M. (2013b). Stages in physical literacy journey. *ICSSPE Bulletin—Journal of Sport Science and Physical Education*, 65, 52–57. <https://www.physical-literacy.org.uk/research/icsspc-bulletin-65/>
- Wolman, L., & Fraser-Thomas, J. (2017). “I Am a lifer!” facilitating the transition into non-elite adult sport: A case study of rugby in Canada’s largest city. *Psychology of Sport & Exercise*, 30(Supplement C), 215–225. <https://doi.org/10.1016/j.psychsport.2017.03.008>
- Young, L., Alfrey, L., & O'Connor, J. (2023). Moving from physical literacy to co-existing physical literacies: What is the problem? *European Physical Education Review*, 29(1), 55–73. <https://doi.org/10.1177/1356336X221112867>

Appendix

Table A1. The PLAS

Stem	Item
Why do you practice your chosen form of physical activity?	(1) For the pleasure it gives me to know more about the activity I practice. (2) Because it is one of the best ways I have chosen to develop other aspects of my life. (3) For the pleasure I feel while improving some of my weak points. (4) For the excitement I feel when I am really involved in the activity. (5) For the pleasure of discovering new performance strategies.
I feel things have gone well in my activity when...	(6) I make some good friends with other members. (7) I make new friends who I socialize with outside of the sport/activity. (8) I have fun with the other members. (9) Just hanging out with others is fun.
How certain are you right now that you could exercise three times per week for 20 minutes if:	(10) The weather was bothering you. (11) You felt pain when exercising. (12) You did not enjoy it. (13) You were too busy with other activities. (14) You felt tired.
How True (like you) or how False (unlike you), is each statement as a description of you.	(15) Physically I have good coordination. (16) I am not physically strong. (17) I am stronger than other people my age. (18) I am a physically strong person. (19) I am good at activities where I have to use physical co-ordination. (20) I have good balance and coordination.
To what extent do you agree or disagree with the following statements about physical activity and health?	(21) Taking the stairs at work or generally being more active for at least 30 minutes each day is enough to improve your health. (22) Half an hour of brisk walking on most days is enough to improve your health. (23) Moderate exercise that increases your heart rate slightly can improve your health.