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Original research

Reliability and validity of the adapted Resistance Training Skills Battery for Children

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ABSTRACT

Objectives: Resistance training (RT) is emerging as a training modality to improve motor function and facilitate physical activity participation in children across the motor proficiency spectrum. Although RT competency assessments have been established and validated among adolescent cohorts, the extent to which these methods are suitable for assessing children's RT skills is unknown. This project aimed to assess the psychometric properties of the adapted Resistance Training Skills Battery for Children (RTSBc), in children with varying motor proficiency.
Design: Repeated measures design with 40 participants (M age = 8.2 ± 1.7 years) displaying varying levels of motor proficiency.
Methods: Participants performed the adapted RTSBc on two occasions, receiving a score for their execution of each component, in addition to an overall RT skill quotient child (RTSQc). Cronbach's alpha, intra-class correlation (ICC), Bland–Altman analysis, and typical error were used to assess test–retest reliability. To examine construct validity, exploratory factor analysis was performed alongside computing correlations between participants' muscle strength, motor proficiency, age, lean muscle mass, and RTSQc.
Results: The RTSBc displayed an acceptable level of internal consistency (alpha = 0.86) and test–retest reliability (ICC range = 0.86–0.99). Exploratory factor analysis supported internal test structure, with all six RT skills loading strongly on a single factor (range 0.56–0.89). Analyses of structural validity revealed positive correlations for RTSQc in relation to motor proficiency ($r = 0.52$, $p < 0.001$) and strength scores ($r = 0.61$, $p < 0.001$).
Conclusions: Analyses revealed support for the construct validity and test–retest reliability of the RTSBc, providing preliminary evidence that the RTSBc is appropriate for use in the assessment of children's RT competency.

1. Introduction

Childhood physical activity (PA) is linked with physical health benefits, and increased psychological well-being.[1,2] During childhood and adolescence, PA levels play a vital role in physical and neurocognitive development, and establishing mechanisms for lifelong engagement in PA.[3] However, childhood involvement in PA is declining, as few as one in five children meet current PA recommendations.[4] Alongside cardiorespiratory fitness, motor proficiency and body composition, muscle strength plays a vital role in supporting the development of fundamental movement skills (FMS) and resultant PA participation in children.[5]

To achieve proficiency in the performance of basic FMS, children require adequate muscle strength.[6] Without this, children may have difficulty developing proficient FMS early in life, and therefore the physical and psychosocial competencies that support participation in PA through adolescence and into adulthood.[7] Given the links between movement proficiency, muscular strength and PA, recent research examining exercise interventions has advocated strength-based activities and resistance training (RT) as safe and efficacious modalities to enhance PA participation, provided that education and qualified instruction are available.[2,8,9]

Global public health[10] recommendations aim to increase participation in strengthening activities for children[1] to improve muscular fitness (i.e., strength, endurance, and power), improve

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body composition, enhance bone mineral density and reduce the risk of injuries in sport and PA.[1] Furthermore, there is evidence for RT as a valuable treatment approach in enhancing motor function in children across the motor proficiency spectrum, and for those with movement difficulties.[12,13,14] However, it is crucial to determine whether children can safely coordinate and control loaded movements before encouraging participation in RT.

Assessments of strength variables typically utilise product or outcome based muscular fitness tests, as opposed to providing meaningful feedback on movement technique.[8,15] In contrast to outcome oriented tests, process-orientated measures focus primarily on technique, and involve assessing movement skill competency via the presence or absence of certain performance criteria regarded as essential for successful completion of a skill. This type of assessment can provide specific constructive feedback to assessors, regarding which criteria requires improvement in order to master the movement. Recently, Lubans et al.[16] developed the Resistance Training Skills Battery (RTSB), a process based measure of RT competency in adolescents.[16]

Lubans et al.[16] designed the RTSB to serve a number of purposes, including assessment and feedback for individuals, evaluating the efficacy of RT programs and as a measurement tool for RT specific skill competency.[16] In adolescents, the six skills within the RTSB and the composite resistance training skill quotient (RTSQ) have demonstrated reliability (intraclass correlations = 0.67–0.88) and validity (typical error for individual skills $\leq$1.2 and $\leq$2.5 for RTSQ), making it an effective tool to determine a ranking based on RT skill proficiency, and detect small changes in technique over time, for adolescents.[16,17]

The RTSB has undergone adaptation for use with children 6–12 years of age (RTSBc) and there is evidence for its inter-trial and interrater reliability.[18] Therefore, this paper aims to provide evidence related to the construct and external validity of the adapted RTSBc. Based on the original development, reliability and validity of the RTSB for adolescence,[16,17] we hypothesised that scores derived from the adapted RTSBc would demonstrate evidence of test–retest reliability, as indicated through intraclass correlation coefficients exceeding 0.70.[16] Secondly, with respect to the structural properties of the RTSBc, we hypothesised that factor analytic methods would demonstrate that the six individual RT skills load meaningfully onto a single factor (i.e. RTSQc). Finally, in terms of the external validity of the RTSBc, we hypothesised that RTSBc scores would be positively correlated with motor proficiency and strength indices, as well as with age and lean mass.

2. Methods

Forty children were recruited who met the following selection criteria: aged between 6–12 years; written consent of parent/guardian and verbal assent of child; and no comorbidities that prevented PA. Approval was obtained from the relevant Human Research Ethics Committee (RA/4/1/7174).

Participants attended three sessions, with sessions two and three separated by a period of seven days. In session one, variables such as sex, age, anthropometry, body composition via Dual Energy X-ray Absorptiometry (DEXA) and motor proficiency via the Movement Assessment Battery for Children-2 (MABC-2)[19] were collected. A detailed description of the testing protocols has been previously published.[18] Participants then performed the RTSBc, and five-repetition maximum (5-RM) strength assessments in sessions two and three (detailed below). Parents were asked not to watch any assessments due to potential performance changes but did remain on-site during testing.

The RTSBc was administered according to procedures previously published and appropriate for children (Fig. S1).[16,17,18] Before performing each of the six RT skills, participants observed movement demonstrations and received specific verbal instruction pertaining to the desired movements. Participants were given a 'practice' attempt on each skill to ensure comprehension of instructions with additional instruction provided if the task was not understood. General encouragement was provided during performance, but no skill-related feedback was provided. Participants completed two sets of four repetitions for each of the six RT skills in the following order: (i) push-up, (ii) step-up, (iii) body-weight squat, (iv) standing overhead press, (v) front support with chest touches and (vi) suspended row. Participants were given 20–30 s to recover between sets and exercises.

Scoring of the RTSBc was based on the best repetition performance score in each set of the six RT skills. Each skill has specific performance criteria and participants were awarded a '1' for each criterion correctly demonstrated and a '0' if it was performed incorrectly. Competency in individual RT skills is achieved if specific performance criteria are satisfied, and competency across all six individual skills is required to be considered 'ready' to begin RT.[18] Totals for the two sets were added to obtain a raw RT skill score for each exercise, which was then summed for the RTSQc (possible range 0–56).

The 5-RM strength tests consisted of three RT exercises (chest press, leg press and pull down) performed on specialised paediatric pin-loaded machines. Immediately before the test, participants performed a five-minute general warm-up on a stationary cycle. After explanation and demonstration of correct technique, the participants became familiarised with the movement by performing 10 repetitions at the lowest load, with emphasis being placed on correct technique. The importance of safe and effective lifting was continuously reiterated and the published protocols for maximal strength testing in children were followed throughout.[11,20]

Participants' 5-RM was recorded as the last resistance lifted in which the participant completed five repetitions through a full range of motion without compensatory behaviour. A maximum of five sets to reach the participant's 5-RM, with three minutes rest between sets permitted to minimise fatigue. The 5-RM values (kg) for the chest press, leg press and pull down were summed to create a total score representative of whole body strength, hereafter labelled muscle strength.

Statistical analysis was performed using Statistics Package for the Social Sciences Version 20.0 (SPSS, Inc., Chicago, IL, USA) and alpha levels were set at $p \leq 0.05$. Descriptive statistics were reported as mean (*M*) values with standard deviation (*SD*). To address the first hypothesis, intraclass correlation coefficient (ICC) and inter-trial differences were calculated, along with Bland–Altman analysis, to verify the test–retest reliability of the individual RTSB skills and the RTSQc. Inter-trial differences were calculated by subtracting S1*diff* from S2*diff*. Typical error was also computed, to identify the RTSBc's sensitivity to change.

To address the second hypothesis, exploratory factor analysis with oblimin rotation was employed to empirically test the underlying factorial validity of the six RT skills of the RTSBc. The postulated model hypothesised that the six RTSB skills are the manifestation of one latent factor, namely RT skill competency. A factor was extracted if the eigenvalue of the factor was greater than one.[21] The scree plot was visually examined to confirm the extracted factors were above or at a sharp break between the slopes of the factors. The rotated factor loadings were calculated between the score of each skill and its extracted factors. In interpreting the strength of factor loadings, we were guided by Comrey and Lee's recommendations[22] (i.e., >0.55 = good, 0.45–0.55 = fair, 0.32–0.45 = poor, <0.32 = should not be interpreted).

Finally, the external validity of the RTSBc was examined (i.e., relationships between RTSBc scores and anticipated correlates), Pearson product-moment correlation coefficients were calculated