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Prevalence and Correlates of Resistance Training Skill Competence in Adolescents

Jordan J. Smith[1§], Matthew DeMarco[2], Sarah G. Kennedy[1], Mark Kelson[3], Lisa M. Barnett[4], Avery D. Faigenbaum[5], & David R. Lubans[1]

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[1]Priority Research Center for Physical Activity and Nutrition, University of Newcastle, Callaghan, New South Wales, Australia.

[2]Faculty of Medicine, Medical University of South Carolina, Charleston, South Carolina, United States.

[3]South East Wales Trials Unit, School of Medicine, Cardiff University, Cardiff, United Kingdom

[4]School of Health and Social Development, Deakin University, Melbourne, Victoria, Australia.

[5]Department of Health and Exercise Science, The College of New Jersey, New Jersey, United States.

§Corresponding author

Jordan J. Smith, PhD
Priority Research Centre for Physical Activity and Nutrition
School of Education
Faculty of Education and Arts
University of Newcastle
Callaghan NSW Australia 2308
Email: jordan.smith@newcastle.edu.au
Telephone: +61 2 4921 7704
Fax: +61 2 4921 2084

Author contact details:

Matthew Demarco: demarcmt@email.sc.edu
Sarah G Kennedy: sarah.kennedy@newcastle.edu.au
Mark Kelson: kelsonMJ@cardiff.ac.uk
Lisa M Barnett: lisa.barnett@deakin.edu.au
Avery D Faigenbaum: faigenba@tcnj.edu
David R Lubans: david.lubans@newcastle.edu.au

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ABSTRACT

The aim of this study is to examine the prevalence and correlates of adolescents' resistance training (RT) skill competence. Participants were 548 adolescents (14.1±0.5 years) from 16 schools in New South Wales, Australia. RT skills were assessed using the Resistance Training Skills Battery. Demographics, BMI, muscular fitness, perceived strength, RT self-efficacy, and motivation for RT were also assessed. The proportion demonstrating 'competence' and 'near competence' in each of the six RT skills were calculated and sex differences explored. Associations between the combined RT skill score and potential correlates were examined using multi-level linear mixed models. Overall, the prevalence of competence was low (range=3.3% to 27.9%). Females outperformed males on the *squat*, *lunge* and *overhead press*, whereas males performed better on the *push-up* (p<.05). Significant associations were seen for a number of correlates, which largely differed by sex. Muscular fitness was moderately and positively associated with RT skills among both males (β=0.34, 95%CIs=0.23 to 0.46) and females (β=0.36, 95%CIs=0.23 to 0.48). The proportion of adolescents demonstrating competence was low, but a meaningful proportion achieved near competence. Our findings support a link between RT skills and muscular fitness. Other associations were statistically significant but small in magnitude, and should therefore be interpreted cautiously.

INTRODUCTION

The importance of physical activity for the physical and psychological health of children and adolescents is widely recognised (Janssen & LeBlanc, 2010; Lubans et al., 2016a). However, global estimates suggest 80% of 13-15 year olds fail to accrue the amount of physical activity required to achieve health benefits (Hallal et al., 2012). Although physical activity guidelines typically focus on the promotion of aerobic activities (e.g., running, cycling) (Myer et al., 2015), more recent data have highlighted the unique and complementary benefits of muscle-strengthening physical activities (hereafter referred to as resistance training [RT]) for children and adolescents (Lloyd et al., 2014; Smith et al., 2014a). In response, global physical activity guidelines now recommend school-aged youth participate in RT on at least three days per week (World Health Organization, 2010). Physical activities that specifically target the musculoskeletal system may provide protection against fractures (Behringer et al., 2014), unhealthy weight gain (Artero et al., 2013), and metabolic disorders (Artero et al., 2011). In addition, such activities have been shown to improve psychological health (Lloyd et al., 2014; Lubans et al., 2016b) and reduce the risk of sports-related injuries in young athletes (Lloyd et al., 2014). Despite these benefits, few young people regularly participate in RT (Hulteen et al., 2017), and there is a notable lack of research examining the correlates of participation.

Recently, there has been increasing interest in the associations between motor competence, physical activity and health outcomes (e.g., physical fitness, weight status) (Barnett et al., 2016a; Lubans et al., 2010; Stodden et al., 2008). Although various terminologies have been used in the literature (e.g., motor/movement: coordination, skills, abilities, proficiency, and performance), the term ‘motor competence’ is used herein to describe proficiency in the range of motor skills that enable goal-directed human movement (Robinson et al., 2015). To date, much of the research exploring the links between motor competence and health has focused on a specific set of gross motor skills, termed fundamental movement skills (FMS)(Lubans et al., 2010). FMS testing batteries have tended to focus on several locomotor (e.g., running, jumping), stability (e.g., static balance), and object-control (e.g., catching, throwing) skills, considered to be the 'building blocks' for more specialised sports-specific movements (Gallahue & Ozmun, 2006). While the importance of FMS competence for physical activity participation is becoming increasingly established (Robinson et al., 2015), research in this area has focused on the associations between FMS competence and physical activity participation (particularly participation in organised sports). FMS competence may also be relevant to 'lifelong' physical activities such as RT (Hulteen et al., 2015). However, it is also feasible that our understanding of FMS might expand to include other 'foundational' skills that could be considered relevant to RT (Barnett et al., 2016b).

Early exposure to enriching strength and skill-based activities might be particularly important for future physical activity (Myer et al., 2015). However, perceptions of competence may be a significant barrier to participation. Indeed, a popular model developed by Stodden and colleagues suggests that both 'actual' and 'perceived' motor competence are important determinants of youths' physical activity behaviour (Stodden et al., 2008), and empirical support for these associations continues to build in the literature (Robinson et al., 2015). In addition to facilitating safe and effective participation in RT, developing competence in RT skills might support self-efficacy beliefs, promote positive physical self-perceptions, and enhance motivation for RT (given the status of 'competence' as a theoretical antecedent of motivation (Ryan & Deci, 2000)). However, there is currently little evidence specific to RT from which to draw conclusions. Although RT is a beneficial, feasible, and recommended physical activity option for school-aged youth, very little is known about young peoples' competence in RT skills, or the links between RT skills and health-related outcomes. To address this gap in the literature, the aims of the present study are: (i) to quantify the prevalence of competence in RT skills among a sample of adolescents; and (ii) to explore cross-sectional associations between RT skill competence and a range of potential correlates.

METHODS

Participants and procedure

Data were drawn from participants taking part in the NEAT and ATLAS 2.0 cluster randomised controlled trial (RCT) (Lubans et al., 2016c). NEAT and ATLAS 2.0 was a school-based physical activity intervention conducted in 16 public secondary schools in New South Wales (NSW), Australia. Approval was obtained from the University (H-2014-0312) and Department of Education (SERAP: 2012121) ethics committees, and informed consent/assent from parents/students was received prior to enrolment. A full description of the study protocols is available elsewhere (Lubans et al., 2016c). Male and female adolescents in grade 9 (third year of secondary school) were recruited and assessed (April-June, 2015). Assessments were conducted at the study schools by trained research assistants and undergraduate student volunteers. Demographic data (e.g., age, sex, residential postal code [i.e., to determine socioeconomic status], cultural background) and self-report measures were collected using an online survey, and fitness and anthropometric data were collected with sensitivity and respect for students (e.g., height and weight assessed out of the view of other students). All assessments were conducted with reference to a measurement protocols manual to ensure consistency between assessors.

Study measures

RT skill competence

RT skills were assessed using video analysis of the Resistance Training Skills Battery (RTSB)(Lubans et al., 2014). The construct validity (r = .40, p < .001), test-retest reliability (ICC = .88) and inter-rater reliability (CV = 4.9%) of the RTSB have previously been established (Barnett et al., 2015; Lubans et al., 2014). The RTSB includes six foundational RT movements completed in the following order: *squat*, *push-up*, *lunge*, *overhead press* (with ~2kg bar), *front support with chest touches*, and *suspended row*. After viewing a sex-matched demonstration video pre-recorded on an electronic tablet, participants performed two trials of four repetitions of the selected skill (i.e., eight repetitions per skill), with a rest period of approximately 15 seconds between trials. Participants received adequate rest (i.e., ~3 to 5 mins) between separate RT skills to ensure that fatigue did not adversely influence their performances. Assessors were instructed not to give skill-specific feedback to students, but general encouragement was provided.

Following the collection of data, two assessors viewed the video footage and coded participants' skill performances using pre-specified criteria (Supplementary Figure 1). Each RT skill has either four or five corresponding performance criteria and participants received a score of 1 ('satisfied') or 0 ('not satisfied') for each criterion. As each skill is performed twice, participants can achieve a maximum score of 8 or 10 for each skill, depending on the number of performance criteria. For the current study, competence in RT skills was determined using the higher scoring trial. For example, if a participant received a score of 6 for trial one and 8 for trial two, then trial two was used to code for competence. Participants were considered 'competent' if they satisfied all performance criteria, whereas 'near competent' was defined as satisfying all but one of the performance criteria. A total skill score, termed the Resistance Training Skills Quotient (RTSQ), was calculated by summing the scores for each skill across the two trials (possible range 0 to 56). Inter-rater agreement using a random subsample of participants was found to be good for each of the individual skills (ICC range = .74 to .96) and for the RTSQ (ICC = .93).

Muscular fitness

Participants completed each fitness test after an explanation and demonstration by the assessor. Upper body muscular fitness was assessed using a 90 degree push-up test (Cooper Institute for Aerobics Research, 1999). Due to sex-related differences in upper body strength, all males were instructed to perform push-ups on their toes whereas all females performed push-ups on their knees. Participants were instructed to complete as many repetitions as possible, in time with a metronome set at 40 bpm (i.e., one repetition every 3 seconds). Beginning in a high plank position, participants lowered themselves in a controlled manner towards the floor until a 90 degree angle was formed at the elbow before returning to the start position. The test concluded when participants could no longer complete repetitions with adequate form (e.g., back no longer kept straight), failed to lower themselves to the required depth on three non-consecutive repetitions (incorrect repetitions not counted), or upon volitional failure.

Lower body muscular fitness was assessed using a standing long jump test (Castro-Piñero et al., 2010). Participants stood with their toes behind a marked line and were instructed to jump forward as far as possible, taking off and landing with two feet. Upon landing, the assessor immediately marked the point of contact at the heel of the rearmost foot, and measured the jump distance in centimetres. Participants completed a second repetition after a rest period of no less than 30 seconds, and their longest jump was noted. Both tests are considered valid and reliable field-based measures of muscular fitness among adolescents (Lubans et al., 2011; Ruiz et al., 2010). A muscular fitness composite variable was calculated as the sum of the standardised values (i.e., value – mean/SD) for the two fitness tests, calculated separately for males and females (Artero et al., 2011).

Body mass index (BMI)

Height was measured to the nearest 0.1cm in light clothing without shoes using a portable stadiometer (Model no. PE087, Mentone Educational Centre, Australia), and weight was measured to the nearest 0.5kg using a portable digital scale (Model no. UC-321PC, A&D Company Ltd, Tokyo Japan). BMI was calculated using the standard equation (weight [kg] / Height [m]^2), and weight status was determined using age- and sex-specific BMI *z*-scores and International Obesity Task Force (IOTF) cut-offs (Cole & Lobstein, 2012).

Self-efficacy for RT

Self-efficacy was assessed using a brief scale designed specifically for use with adolescents (Lubans et al., 2011). Students responded to four-items using a 5-point Likert scale (1 = *Strongly disagree* to 5 = *Strongly agree*) (e.g., *I have the skill and technique to complete resistance training exercises safely*). The internal consistency of items for this scale in the present sample was found to be adequate (Cronbach's α = .79).

Perceived strength

Perceived strength was assessed using a single item from the International Fitness Scale (IFIS) (Sánchez-López et al., 2015). Students were asked to consider their 'muscular strength' in relation to their peers and responded using a 5-point scale (1 = *Very poor* to 5 = *Very good*).

Autonomous motivation for RT

Autonomous motivation was assessed using a modified version of the Behavioral Regulations in Exercise Questionnaire – Version 2 (BREQ-2) (Markland & Tobin, 2004). The original BREQ-2 was designed to assess motivation for 'exercise' more broadly (e.g., *I value the benefits of exercise*). For the present study, the items were adapted to focus specifically on RT (e.g., *I value the benefits of resistance training*), and students responded using a 5-point scale (1 = *Not true for me* to 5 = *Very true for me*). The BREQ-2 includes subscales for intrinsic and identified regulations, and the mean of these subscales is calculated to create an autonomous motivation variable. Among the present sample, the internal consistency of items for the intrinsic (Cronbach's $\alpha = .90$) and identified (Cronbach's $\alpha = .84$) subscales was found to be good.

Statistical analysis

All analyses were conducted in SPSS for Windows, version 24 (SPSS Inc., IBM Corp., Armonk, NY), with statistical significance set at $p \leq .05$. Descriptive statistics (i.e., proportions with 95% Confidence Intervals [CIs]) are presented to describe the prevalence of competence and near competence for each of the six RT skills among the entire sample and also separately by sex. Sex-differences in each of the RT skills and the RTSQ were explored first using multi-level linear mixed models (i.e., students nested in schools). Univariate associations between the RTSQ and each of: SES (based on residential postal code), BMI, muscular fitness score, perceived strength, RT self-efficacy and autonomous motivation for RT, were then explored using multi-level models conducted separately for males and females. Fully adjusted models are also presented, controlling for all of these variables simultaneously. Model results are summarised using point estimates, 95%CIs and *p*-values. The intra-class correlation coefficients for school are also presented.

RESULTS

A total of 548 adolescents (mean age = 14.1 ± 0.5 years; 49.6% female) from 16 secondary schools provided complete data for all RT skills, and were included in the study. Demographic data for the study sample can be seen in Table 1. Briefly, the majority were born in Australia (88.3%), identified their cultural background as Australian (65.3%), and spoke English as their primary language at home (90.1%). Approximately two thirds of adolescents were classified as healthy weight, whereas just over a quarter were classified as overweight (20.1%) or obese (5.7%). A small proportion of adolescents (3.9%) were classified as underweight.

Prevalence of competence in RT skills

The proportion of adolescents classified as competent and near competent for each of the six RT skills is presented in Table 2 and depicted in Figure 1 (stratified by sex). Overall, the prevalence of competence was low, ranging from 3.3% (95%CIs = 2.1 to 5.1) for the *front support with chest touches* to 27.9% (95%CIs = 24.3 to 31.8) for the *push-up.* The proportion of adolescents demonstrating near competence was higher and ranged from 13.5% (95%CIs = 10.9 to 16.6) for the *front support with chest touches* to 51.5% (95%CIs = 47.3 to 55.6) for the *overhead press*. Very few adolescents demonstrated competence in multiple skills, with only 6.9% (95%CIs = 5.1 to 9.4) considered competent in ≥ 3 skills, and none competent in all six. Conversely, 30.8% (95%CIs = 27.1 to 34.8) demonstrated near competence for ≥ 3 skills, but no students demonstrated near competence for all six.

Differences in RT skills by sex

Males performed significantly worse than females on the *squat* (-0.56 units, 95%CIs = -0.96 to -0.16), *lunge* (-0.58 units, 95%CIs = -0.92 to -0.24), and *overhead press* (-0.47 units, 95%CIs = -0.73 to -0.20), whereas males outperformed females on the *push-up* (1.22 units, 95%CIs = 0.93 to 1.50). Although statistically significant, most of these differences were trivial. No significant sex differences were found for the *suspended row* (0.17 units, 95%CIs = -0.47 to 0.13) or *front support with chest touches* (-0.06 units, 95%CIs = -0.23 to 0.36). There was also no significant difference between males and females for the RTSQ (-0.38 units, 95%CIs = -0.67 to 1.43).

Associations between RT skills and potential correlates

Associations between the RTSQ and potential correlates for males and females are presented in Tables 3 and 4, respectively. SES was not associated with RTSQ in the univariate or adjusted models for either sex (p >.05 for all). In univariate analyses, muscular fitness, RT self-efficacy, and autonomous motivation were significantly associated with RTSQ for both sexes, whereas perceived strength and BMI were significant only for females. In the adjusted models, muscular fitness was significantly associated with RTSQ for both males (β = 0.31, 95%CIs = 0.21 to 0.42) and females (β = 0.33, 95%CIs = 0.21 to 0.45). In addition, small but significant independent associations were found for perceived strength (β = -0.14, 95%CIs = -0.26 to -0.01) and autonomous motivation (β = 0.16, 95%CIs = 0.06 to 0.27) among males, and for BMI (β = -0.18, 95%CIs = -0.29 to -0.07) among females. Given the significant association for BMI, differences in females' RT skills between weight status groups were explored using ANOVA with Tukey post-hoc tests (Figure 2). Healthy weight females were significantly more skilled (F [3, 264] = 15.5, p < .001) than their overweight (5.3 units, 95%CIs = 2.5 to 8.1) and obese (9.5 units, 95%CIs = 4.7 to 14.3) peers.

DISCUSSION

Motor competence is an important driver of physical activity behaviour (Barnett et al., 2009; Stodden et al., 2008), yet there is very little evidence regarding young peoples' competence in RT skills. The aims of the present study were to: (i) quantify the prevalence of competence and near competence in RT skills, and (ii) explore potential correlates of RT skill competence among a sample of adolescents. Overall, we found the proportion of adolescents demonstrating competence in each of the RT skills was low. Small sex differences in specific RT skills were apparent, but there was essentially no difference in overall RT skill competence between the sexes. Additionally, small to moderate associations between RT skills and a number of potential correlates were found, which largely differed by sex.

The skills with the highest prevalence of competence were the *push-up* (29.7%) and *lunge* (26.8%), whereas competence was lowest for the *suspended row* (4.7%) and *front* *support with chest touches* (3.3%). Although these data might suggest adolescents have quite poor RT skills, there was a considerable proportion classified as near competent. Interestingly, females outperformed males on three of the six skills (i.e., *squat*, *lunge* and *overhead press*), whereas there was only one skill in which males performed better (i.e., *push-up*). Systematic review evidence shows that males typically have better object control skills and motor coordination than females, but that a child's sex is not associated with locomotor competence (Barnett et al., 2016a). Females' superior performance on the above-mentioned RT skills could be explained by sex differences in flexibility, as recent research identified an association between motor competence and flexibility in children (Lopes et al., 2016). Indeed, while males typically outperform females in the majority of health-related fitness measures, data consistently show that females are more flexible than males (Ortega et al., 2011; Tremblay et al., 2010). Scoring highly on the squat and lunge, in particular, requires an extended range of motion throughout the movement. It is plausible that females' greater flexibility enabled them to execute these skills more effectively, resulting in the small but significant differences observed.

The low prevalence of RT skill competence is perhaps not surprising, given few school-aged youth will have received formal RT instruction. For example, surveillance data suggest only 0.3% to 12.4% of adolescents worldwide participate in RT (Hulteen et al., 2017). Despite evidence to the contrary (Lloyd et al., 2014), many parents feel RT is an inappropriate or unsafe activity for children and adolescents (ten Hoor et al., 2015), and PE programs usually focus on traditional team sports (and associated motor skills) (Ennis, 2014). For these reasons, many youth are not exposed to specialist RT instruction. Learning experiences that include explicit instruction on how to perform RT movements correctly can improve motor skill competence (Behringer et al., 2011; Faigenbaum et al., 2015). For example, we have previously shown that a school-based program designed to support adolescents' RT skill development had both an immediate (Smith et al., 2014b) and sustained (Lubans et al., 2016d) impact on RT skill competence. These findings suggest schools can play an important role in supporting students' RT skill development.

To the authors' knowledge, this is the first study to explore the correlates of RT skill competence. We found muscular fitness was significantly associated with RT skills in both sexes, independent of multiple confounding variables. Stodden and colleagues posit a synergistic relationship between motor competence and health-related fitness (Stodden et al., 2008), which interact to promote either positive or negative health trajectories over time. While there is emerging evidence to support the causal link between FMS development and improved aerobic fitness (Cohen et al., 2015), few prior studies have examined the links between health-related fitness components and RT skills. Our findings are consistent with a recent synthesis of the literature, which supported a positive association between motor competence and health-related fitness in youth (Robinson et al., 2015). Although causation cannot be determined in the present study, the association for muscular fitness was of moderate strength, was consistent across sexes, and is in line with the hypotheses proposed by Stodden and colleagues' model (Stodden et al., 2008). Furthermore, we have previously reported that improvements in RT skills partially mediated improvements in muscular fitness in a school-based intervention for adolescent boys (Smith et al., 2016). While a reciprocal relationship is probable (Barnett et al., 2011), targeting RT skill development may be a useful strategy for improving muscular fitness during adolescence. However, it is important to recognise that any movement performance requires some level of muscular fitness. Therefore, low muscle strength and endurance could be a risk factor for sub-optimal motor development (Faigenbaum & MacDonald, 2017).

Regarding weight status, our findings partially support this association, as BMI was significantly associated with RT skills among females. However, it should also be noted that the magnitude of the association was small and may not be practically meaningful (Ferguson, 2009). It might be that this relationship is non-linear, which could explain the small standardised beta coefficient. Indeed, there were notable differences in skill competence between healthy weight females and their overweight and obese peers, but not between underweight and healthy weight females. Alternatively, it may be that lack of competence in traditionally defined FMS, including both locomotor (e.g., run) and object-control (e.g., overhand throw) skills, is more strongly related to unhealthy weight gain in this group (Cliff et al., 2012). As for perceived strength, RT self-efficacy and autonomous motivation among males, the coefficients (although statistically significant and independent of other variables) were below the threshold of $\beta = 0.20$ previously defined as the recommended minimal magnitude for assuming practical significance (Ferguson, 2009). Consequently, the 'real world' importance of these associations should be interpreted cautiously.

Strengths of the present study include the objective assessment of RT skills among a relatively large sample of adolescents, and the robust cross-sectional analysis. However, participants were all from a single school grade, and caution should be taken when generalising findings to younger or older youth. Also, the study sample were recruited to participate in a school-based physical activity intervention, and there is the potential for selection bias and non-representativeness. Despite this, obesity prevalence in the study sample roughly mirrors that of the broader adolescent population (O'Dea & Dibley, 2014), and there were approximately equal numbers of males and females included. Consequently, the sample may nonetheless be representative of Australian adolescents. It should also be noted that maturation was not assessed as part of this study. Therefore, it is not possible to ascertain whether gender differences in RT skills are due to differences in maturity status that might be present between males and females at this age. Finally, given the cross-sectional nature of this study, the direction of the associations cannot be determined.

CONCLUSIONS

Our findings suggest adolescents' competence in basic RT skills is low, but also that a meaningful proportion are close to achieving competence. Sex differences in RT skills were either small or non-significant, which likely reflects the limited experience most adolescents (both male and female) will have had with RT at this age. Muscular fitness was positively associated with RT skills among both sexes, which is consistent with theoretical hypotheses and the findings of recent empirical research. Although RT skills were independently associated with RT self-efficacy (marginal), perceived strength and motivation for RT in males, the magnitude of these associations were small and should therefore be interpreted with caution. The association between girls' RT skills and weight status might have practical importance, and could be further explored in future research. Future research should also explore RT skill competence in primary/elementary school children, as RT is recommended for this age group. In addition, studies examining the directionality of associations using longitudinal and experimental designs is warranted.

The findings of this research are relevant to physical educators and youth sport coaches who are considering delivering RT in school or community sport settings. Our findings suggest the majority of adolescents will require meaningful instruction in basic RT movements prior to progressing to more complex RT programs. The RTSB appears to be a useful screening tool for identifying adolescents that are ready to move to a structured progressive RT program, as well as those that will first require formal instruction in the basic movement sequences. Consistent with current youth RT guidelines that emphasise motor skill development as a key outcome of training (Lloyd et al., 2014), we suggest children and adolescents demonstrate competence in these foundational skills before using external resistance. Doing so may help them to develop self-efficacy, whilst participating in RT safely and effectively.

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Table 1. Characteristics of study sample

Characteristics	**All (*N* = 548)**	**Males (*n* = 276)**	**Females (*n* = 272)**
Age, mean (SD), years	14.1 (0.5)	14.1 (0.5)	14.1 (0.4)
Born in Australia, n (%)	481 (88.3)	248 (90.5)	233 (86.0)
English language spoken at home, n (%)	491 (90.1)	245 (89.4)	246 (90.8)
Cultural background, n (%)			
Australian	356 (65.3)	173 (63.1)	183 (67.5)
European	46 (8.4)	25 (9.1)	21 (7.7)
African	4 (0.7)	1 (0.4)	3 (1.1)
Asian	73 (13.4)	40 (14.6)	33 (12.2)
Middle eastern	10 (1.8)	6 (2.2)	4 (1.5)
Other	56 (10.3)	29 (10.6)	27 (10.0)
Socioeconomic status, n (%)			
1-2	64 (11.8)	35 (12.8)	29 (10.8)
3-4	136 (25.1)	68 (25.0)	68 (25.3)
5-6	202 (37.3)	85 (31.2)	117 (43.5)
7-8	22 (4.0)	15 (5.5)	7 (2.6)
9-10	118 (21.7)	70 (25.7)	48 (17.8)
BMI, mean (SD), $kg.m^{-2}$	22.1 (4.0)	21.9 (4.1)	22.3 (3.9)
Weight status, n (%)			
Underweight	21 (3.9)	10 (3.7)	11 (4.1)
Healthy weight	370 (68.4)	184 (67.4)	186 (69.4)
Overweight	109 (20.1)	54 (19.8)	55 (20.5)
Obese	41 (7.5)	25 (9.2)	16 (6.0)
Resistance training skills, mean (SD)			
Squat (/10)	6.1 (2.4)	5.8 (2.4)	6.3 (2.4)
Lunge (/10)	7.1 (2.2)	6.8 (2.2)	7.3 (2.2)
Push-up (/8)	5.1 (2.1)	5.7 (2.1)	4.6 (2.1)
Overhead press (/10)	7.4 (1.6)	7.2 (1.6)	7.6 (1.6)
Suspended row (/8)	4.1 (1.8)	4.2 (1.8)	4.0 (1.8)
Front support with chest touches (/10)	5.2 (1.7)	5.2 (1.7)	5.2 (1.7)
Resistance Training Skill Quotient (/56)	35.0 (7.3)	34.9 (7.7)	35.0 (7.7)

Note. Data collected in New South Wales, Australia (April-June, 2015)

Table 2. Prevalence of competence and near competence in resistance training skills among adolescents[a]

Resistance training skills	All (N = 548)		Males (n = 276)		Females (n = 272)	
	Prevalence (%)	95% CIs	Prevalence (%)	95% CIs	Prevalence (%)	95% CIs
Squat						
Competent	12.8	10.2 to 15.8	8.0	5.3 to 11.8	17.6	13.6 to 22.6
Near Competent	27.6	24.0 to 31.4	29.3	24.3 to 35.0	25.7	20.9 to 31.2
< Near Competent	59.7	55.5 to 63.7	62.7	56.8 to 68.2	56.6	50.7 to 62.4
Lunge						
Competent	26.8	23.4 to 30.7	21.7	17.3 to 27.0	32.0	26.7 to 37.7
Near Competent	39.8	35.8 to 43.9	40.2	34.6 to 46.1	39.3	33.7 to 45.3
< Near Competent	33.4	29.6 to 37.4	38.0	32.5 to 43.9	28.7	23.6 to 34.3
Push-up						
Competent	27.9	24.3 to 31.8	37.3	31.8 to 43.2	18.4	14.2 to 23.4
Near Competent	27.9	24.3 to 31.8	31.5	26.3 to 37.2	24.3	19.6 to 29.7
< Near Competent	44.2	40.1 to 48.3	31.2	26.0 to 36.9	57.4	51.4 to 63.1
Overhead press						
Competent	16.4	13.6 to 19.8	12.3	9.0 to 16.7	20.6	16.2 to 25.8
Near Competent	51.5	47.3 to 55.6	52.9	47.0 to 58.7	50.0	44.1 to 55.9
< Near Competent	32.1	28.3 to 36.1	34.8	29.4 to 40.6	29.4	24.3 to 35.1
Suspended row						
Competent	4.7	3.3 to 6.9	6.2	3.9 to 9.6	3.3	1.8 to 6.2
Near Competent	31.0	27.3 to 35.0	29.7	24.6 to 35.4	32.4	27.1 to 38.1
< Near Competent	64.2	60.1 to 68.1	64.1	58.3 to 69.6	64.3	58.5 to 69.8
Front support with chest touches						
Competent	3.3	2.1 to 5.1	3.6	2.0 to 6.5	2.9	1.5 to 5.7
Near Competent	13.5	10.9 to 16.6	14.5	10.8 to 19.1	12.5	9.1 to 17.0
< Near Competent	83.2	79.9 to 86.1	81.9	76.9 to 86.0	84.6	79.8 to 88.4

Note. CIs = confidence intervals.
[a] Competent defined as achieving all criteria on the higher scoring trial; Near Competent defined as achieving all but one criteria on the higher scoring trial.

Table 3. Linear mixed models examining associations between RTSQ and potential correlates among males (n = 276)

Variables	Univariate models[a]			Fully adjusted model[b]		
	β (SE)	**95% CIs**	**p value**	**β (SE)**	**95% CIs**	**p value**
SES	-0.07 (0.09)	-0.24 to 0.10	.444	-0.00 (0.08)	-0.16 to 0.15	.958
BMI	-0.06 (0.05)	-0.16 to 0.03	.191	0.05 (0.05)	-0.05 to 0.15	.314
Muscular fitness score	**0.33 (0.05)**	**0.23 to 0.42**	**< .001**	**0.31 (0.05)**	**0.21 to 0.42**	**< .001**
Perceived strength	0.09 (0.05)	-0.01 to 0.19	.069	**-0.14 (0.06)**	**-0.26 to -0.01**	**.028**
RT self-efficacy	**0.21 (0.05)**	**0.12 to 0.31**	**< .001**	**0.12 (0.06)**	**-0.00 to 0.25**	**.050**
Autonomous motivation for RT	**0.24 (0.05)**	**0.14 to 0.34**	**< .001**	**0.16 (0.05)**	**0.06 to 0.27**	**.002**

Note. ICC for school (adjusted model) = 0.363. Significant associations at $p \leq .05$ in bold.
β = standardized regression coefficient; BMI = body mass index; CIs = confidence intervals; RT = resistance training; RTSQ = resistance training skill quotient; SES = socio-economic status; SE = standard error.
[a] Association between independent variable and RTSQ adjusted for school
[b] Association between independent variable and RTSQ adjusted for school and all remaining variables

Table 4. Linear mixed models examining associations between RTSQ and potential correlates among females (n = 272)

Variables	**Univariate models[a]**			**Fully adjusted model[b]**		
	***β* (SE)**	**95% CIs**	***p* value**	***β* (SE)**	**95% CIs**	***p* value**
SES	0.14 (0.09)	-0.03 to 0.31	.106	0.05 (0.08)	-0.11 to 0.21	.527
BMI	**-0.29 (0.05)**	**-0.40 to -0.19**	**< .001**	**-0.18 (0.05)**	**-0.29 to -0.07**	**.001**
Muscular fitness score	**0.46 (0.05)**	**0.35 to 0.56**	**< .001**	**0.33 (0.06)**	**0.21 to 0.45**	**< .001**
Perceived strength	**0.22 (0.05)**	**0.12 to 0.31**	**< .001**	0.05 (0.06)	-0.06 to 0.17	.345
RT self-efficacy	**0.22 (0.05)**	**0.12 to 0.32**	**< .001**	0.03 (0.06)	-0.09 to 0.14	.668
Autonomous motivation for RT	**0.18 (0.05)**	**0.08 to 0.28**	**< .001**	0.06 (0.05)	-0.05 to 0.16	.285

Note. ICC for school (adjusted model) = 0.336. Significant associations at $p \leq .05$ in bold.
β = standardized regression coefficient; BMI = body mass index; CIs = confidence intervals; RT = resistance training; RTSQ = resistance training skill quotient; SES = socioeconomic status; SE = standard error.
[a] Association between independent variable and RTSQ adjusted for school
[b] Association between independent variable and RTSQ adjusted for school and all remaining variables