ORIGINAL ARTICLE

Comparative analysis of muscular fitness tests and their correlation with anthropometric data in children aged 9-12

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ABSTRACT

Physical fitness, encompassing cardiorespiratory endurance, muscular strength, and body composition, is vital for health and well-being. Muscular fitness, in particular, is associated with decreased risks of depression, cognitive disorders, and metabolic disease. Despite various available tests to measure muscle strength, there is no consensus on the most effective test or combination of tests, and direct comparisons are scarce. This study evaluated the muscular fitness of 484 children aged 9-12 years (225 girls and 259 boys) through multiple tests, including standing broad jump (SBJ), push-ups, bent-arm hang (BAH), sit-ups, handgrip strength, back-leg dynamometry (back-leg), and medicine ball throw (MBT), to assess their correlation with anthropometric data. Our correlation analysis revealed strong relationships (r > 0.6) between handgrip and MBT, handgrip and back-leg, and MBT and back-leg. However, most correlations were weak or very weak, indicating that different aspects of muscle strength, as assessed by these tests, are largely independent and cannot be substituted for one another. This underscores the necessity of employing a variety of tests in the comprehensive assessment of muscular fitness, taking into account the unique predictive value of each.

Keywords: Physical education, Strength, Physical fitness, Dynamometry.

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INTRODUCTION

Physical fitness is a crucial component of overall health and well-being, with monitoring being essential for analysing the condition of both society and individuals. Its components, as defined by the Cooper Institute (2010), include cardiorespiratory fitness, muscular fitness, and body composition. Muscular fitness is the ability of a muscle or a group of muscles to exert force maximally, swiftly, or repetitively (Fraser et al., 2021). Its importance is underscored by its association with improved health outcomes, such as a reduced risk of depression, cognitive dysfunction, and metabolic disorders. Reflecting these findings, the World Health Organization recommends muscle-strengthening and bone-strengthening activities for children aged 5-17 (Chaput et al., 2020).

The relationship between muscular fitness and health outcomes has been scrutinized through various tests, yet the evidence remains limited. For instance, while handgrip strength is positively associated with adiposity, it correlates negatively with body weight tests such as the vertical jump and standing broad jump (SBJ) (Smith et al., 2014). Cardiovascular disease has been linked to handgrip strength and SBJ (Sánchez-Delgado et al., 2023; Steene-Johannessen et al., 2009), and significant relationships with cardiovascular diseases have also been observed in push-ups, SBJ, and handgrip strength tests (Magnussen et al., 2012). However, data for other tests like the bent-arm hang (BAH), medicine ball throw (MBT), pulling strength dynamometers, and sit-ups remain scarce (Morikawa et al., 2018; Sánchez-Delgado et al., 2023; Smith et al., 2014).

Studies on secular trends in muscular fitness have yielded conflicting conclusions. Đurić et al. (2021) reported a decline in SBJ and BAH (21-42%), but a slight increase in the 60s sit-up test (1.1%). In contrast, Fühner et al. (2021) noted a general trend of a slight increase in relative strength and a negative trend in muscle power. While bodyweight tests are highly reliable, they do not match the accuracy of device measurements. A review analysis by Dooley et al. (Dooley et al., 2020) investigated the long-term trend in handgrip strength, revealing a gradual improvement of 3.8% per decade from 1967 to 2017 for children. Although this trend is well-established, results varied significantly between countries, and in some instances, the trend was reversed, as confirmed by Sandercock & Cohen (2019). Therefore, identifying trends is somewhat contingent on the choice of a specific test.

Assessing certain dimensions of physical fitness in children is a routine practice in most physical education curricula (Veldhuizen et al., 2015). Conducting physical fitness assessments serves as a means to evaluate the current fitness status of children, design customized training programs, monitor progress, stimulate participants, and advance physical education. The choice of test for determining muscular fitness levels varies considerably, and it is unclear which test or combination of tests is optimal. For assessing muscular fitness, bodyweight tests (push-ups, pull-ups, BAH, sit-ups) are often utilized to gauge relative strength and muscular endurance (Fühner et al., 2021; Chen et al., 2018). Exercises with external loads (bench press) are used less frequently. The SBJ is commonly employed to determine muscle power levels, and the MBT to a lesser extent. Handgrip strength is one of the most applied tests, with other devices used sporadically (Dooley et al., 2020). There is a broad spectrum of methods to assess muscle strength levels. Test batteries are also employed; however, the selection of tests is not standardized. Fitnessgram includes curl-up, push-ups, and trunk lift; Eurofit comprises SBJ, handgrip strength, and sit-ups (30s), and BAH; the HELENA study utilized SBJ and BAH, handgrip strength; the IDEFICS study included tests of SBJ and handgrip strength (de Miguel-Etayo et al., 2014; Chen et al., 2018; Moliner-Urdiales et al., 2010; Tomkinson et al., 2018).

No sources known to the authors have specifically compared individual tests of muscular fitness to determine their relationship. It is crucial for practice to ascertain which tests are most appropriate or whether a

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combination of multiple tests is required. This study aims to assess muscular fitness in children aged 9-12 years using a variety of tests, including bodyweight tests, exercises with external loads, and dynamometry. The tests will be analysed to establish their correlation with anthropometric measurements.

METHODS

Participants

The study sample comprised 484 Czech children from public schools, aged 9-12 years (mean age 11.1 ± 0.9 years), including 225 girls and 259 boys. Six schools were randomly selected, and students from grades 3 to 5 were included. All participants were Caucasian. Inclusion criteria were as follows: children within the 9-12 year age range for the duration of the study; absence of significant medical conditions as determined by a standard medical examination; and receipt of parental/legal guardian consent. The study excluded 37 children who did not complete all tests. The sample was stratified by age groups—9-10 (2012), 10-11 (2011), and 11-12 (2010) years—according to birth year. Testing occurred during regular physical education classes over the course of three sessions.

Parents or legal guardians received detailed information about the research process and provided written informed consent. The research was conducted in the latter half of 2022 and received ethical approval from the University of Hradec Kralove Committee for Research Ethics (Approval No. 12/2022), adhering to the Declaration of Helsinki.

Muscular fitness tests

Selected muscular fitness tests were based on established protocols from Fitnessgram, Eurofit, IDEFICS, and HELENA studies. The chosen tests—push-ups, bent-arm hang (BAH), and sit-ups—evaluated relative strength and muscular endurance. Standing broad jump (SBJ) and medicine ball throw (MBT) assessed muscle power. Absolute strength was measured using dynamometers for handgrip strength (MAP 80K1S, KERN. Kern & Sohn GmbH, Germany) and back-leg pulling (SH5007, Saehan Dynamometer. Saehan Corporation, India). These tests were selected to evaluate different muscle groups and aspects of muscular strength. Prior to testing, all children practiced the techniques and were encouraged throughout. Adequate rest periods of 2-5 minutes were provided between each attempt and each test to ensure recovery and maintain motivation. A standard 10-minute dynamic warm-up was completed by all children before testing.

Bent-arm hang (BAH) - the participant is lifted into position with their body raised to a height where their chin is above the bar. Test is stopped when their chin goes below the level of the bar. *Push-ups* – from start position the subject lowers the body until there is a 90-degree angle at the elbows, with the upper arms parallel to the floor. The number of valid repetitions counts. *Sit-ups* – Start lying on the back with the hands on the shoulders and the knees bent, the legs are held by the researcher. The subject must touch the knees with both elbows when lifted. The test is performed for 60 seconds. *Standing broad jump (SBJ)* – the starting position is standing behind the marked line. The participant had to jump and land with both feet at the same time. The distance from the starting line to the point of heel landing is measured. *Medicine ball throw (MBT)* – from a parallel position, the participant throws a medicine ball (3 kg, diameter 30 cm) with both hands from chest level. The distance is measured from the starting line to the point of ball impact. *Handgrip dynamometry (handgrip)* – the subject was standing with his elbow bent. *Pulling back-leg dynamometry (back-leg)* – the participant stands with both feet on the device and holds the handle with both hands at knee level. This motion simulates a partial deadlift.

Table 1. Results of anthropometry and muscular fitness tests.

	Weight (kg)	Height (cm)	BMI	SBJ (cm)	MBT (m)	BAH (s)	Handgrip (kg)	Back-leg (kg)	Push-ups (reps)	Sit-ups (reps)
All										
2012	37.81 (8.76)	144.73 (6.79)	17.96 (3.43)	138.66 (23.16)	3.19 (0.56)	7.05 (7.94)	19.31 (4.16)	53.82 (15.08)	12.14 (10.33)	21.42 (9.54)
2011	42.01 (11.43)	148.85 (8.27)	18.77 (3.88)	147.49 (27.3)	3.48 (0.79)	9.21 (10.49)	21.97 (5.69)	59.57 (17.42)	10.09 (9.28)	22.89 (7.73)
2010	49.06 (12.9)	156.05 (8.66)	19.97 (4.21)	157.17 (25.93)	4.18 (0.85)	8.58 (9.5)	25.87 (5.74)	70.46 (18.23)	10.52 (8.88)	27.45 (9.54)
All	43.49 (12.26)	150.41 (9.28)	18.99 (3.98)	148.7 (26.76)	3.66 (0.86)	8.4 (9.53)	22.7 (5.96)	62.05 (18.44)	10.8 (9.47)	24.18 (9.29)
Girls										
2012	38.41 (8.79)	144.65 (7.21)	18.26 (3.39)	133.2 (23.73)	3.05 (0.56)	7.08 (9.23)	18.74 (3.87)	51.27 (15.39)	10.15 (9.02)	20.94 (10.01)
2011	41.48 (9.32)	149.43 (8.73)	18.42 (3.01)	141.05 (26.96)	3.26 (0.75)	8.16 (9.7)	21.54 (5.59)	56.84 (16.88)	8.91 (9.23)	23.61 (8.01)
2010	50.87 (11.98)	157.15 (7.23)	20.44 (3.94)	151.19 (26.03)	3.94 (0.75)	6.98 (9.42)	25.82 (4.77)	66.58 (14.56)	8.67 (7.84)	27.99 (6.29)
All	43.51 (11.36)	150.39 (9.29)	19.02 (3.58)	141.82 (26.67)	3.41 (0.79)	7.44 (9.48)	22.02 (5.61)	58.2 (16.88)	9.23 (8.76)	24.17 (8.7)
Boys										
2012	37.09 (8.67)	144.82 (6.24)	17.59 (3.45)	145.24 (20.62)	3.35 (0.52)	7 (6.02)	20 (4.38)	56.9 (14.08)	14.53 (11.26)	21.98 (8.92)
2011	42.48 (13)	148.33 (7.81)	19.07 (4.49)	153.16 (26.32)	3.68 (0.77)	10.13 (11.06)	22.35 (5.74)	61.98 (17.52)	11.13 (9.2)	22.25 (7.41)
2010	47.84 (13.34)	155.32 (9.43)	19.65 (4.35)	161.2 (25.07)	4.35 (0.87)	9.66 (9.4)	25.9 (6.3)	73.07 (19.91)	11.77 (9.32)	27.09 (11.2)
All	43.4 (13.04)	150.36 (9.32)	18.95 (4.3)	154.76 (25.34)	5.21 (21.48)	9.26 (9.32)	23.25 (6.18)	65.46 (19.06)	12.27 (9.99)	24.21 (9.76)

Note. SBJ -standing broad jump; MBT – medicine ball throw; BAH – bent-arm hang; Back-leg – Pulling back-leg dynamometry.

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Data analysis

Using the IBM SPSS software, version 20, the Spearman rank correlation coefficient was computed for all the obtained variables. The correlation was assessed in compliance with the following relationships (Abbott, 2011): ≤0.8 very strong relationship, 0.6-0.8 – strong relationship, 0.4-0.6 – moderate relationship, 0.2-0.4 weak relationship, <0.2 very weak relationship. The same software generated descriptive statistics and graphical representations of the data.

RESULTS

The anthropometry values are shown in Table 1. The mean values for all tests are described below. The sample was divided between boys and girls and also into three groups according to the date of their birth.

Table 2. Correlation results between muscular fitness tests and anthropometry.

	Weight (kg)	Height (cm)	BMI	SBJ (cm)	MBT (m)	BAH (s)	Handgrip (kg)	Back-leg (kg)	Push-ups (reps)	Sit-ups (reps)
All										
Weight	1.000	0.680	0.903	-0.090	0.515	-0.287	0.577	0.459	-0.264	-0.014
Height	0.680	1.000	0.314	0.180	0.539	-0.121	0.589	0.458	-0.159	0.195
BMI	0.903	0.314	1.000	-0.204	0.368	-0.309	0.416	0.346	-0.253	-0.126
SBJ	-0.090	0.180	-0.204	1.000	0.464	0.401	0.311	0.330	0.325	0.385
MBT	0.515	0.539	0.368	0.464	1.000	0.144	0.637	0.611	0.120	0.314
BAH	-0.287	-0.121	-0.309	0.401	0.144	1.000	0.111	0.120	0.424	0.303
Handgrip	0.577	0.589	0.416	0.311	0.637	0.111	1.000	0.629	0.067	0.258
Back-leg	0.459	0.458	0.346	0.330	0.611	0.120	0.629	1.000	0.237	0.325
Push-ups	-0.264	-0.159	-0.253	0.325	0.120	0.424	0.067	0.237	1.000	0.373
Sit-ups	-0.014	0.195	-0.126	0.385	0.314	0.303	0.258	0.325	0.373	1.000
Girls										
Weight	1.000	0.711	0.894	-0.040	0.560	-0.301	0.571	0.487	-0.228	0.037
Height	0.711	1.000	0.332	0.260	0.576	-0.106	0.618	0.507	-0.047	0.313
BMI	0.894	0.332	1.000	-0.223	0.393	-0.355	0.378	0.349	-0.285	-0.162
SBJ	-0.040	0.260	-0.223	1.000	0.491	0.353	0.308	0.323	0.314	0.426
MBT	0.560	0.576	0.393	0.491	1.000	0.083	0.607	0.592	0.137	0.372
BAH	-0.301	-0.106	-0.355	0.353	0.083	1.000	0.038	0.077	0.375	0.297
Handgrip	0.571	0.618	0.378	0.308	0.607	0.038	1.000	0.618	0.064	0.308
Back-leg	0.487	0.507	0.349	0.323	0.592	0.077	0.618	1.000	0.206	0.344
Push-ups	-0.228	-0.047	-0.285	0.314	0.137	0.375	0.064	0.206	1.000	0.364
Sit-ups	0.037	0.313	-0.162	0.426	0.372	0.297	0.308	0.344	0.364	1.000
Boys										
Weight	1.000	0.662	0.909	-0.138	-0.062	-0.284	0.589	0.450	-0.303	-0.052
Height	0.662	1.000	0.307	0.111	-0.074	-0.139	0.577	0.429	-0.263	0.100
BMI	0.909	0.307	1.000	-0.203	-0.056	-0.283	0.449	0.352	-0.244	-0.104
SBJ	-0.138	0.111	-0.203	1.000	0.067	0.430	0.282	0.280	0.295	0.376
MBT	-0.062	-0.074	-0.056	0.067	1.000	0.070	-0.056	0.074	0.174	0.042
BAH	-0.284	-0.139	-0.283	0.430	0.070	1.000	0.147	0.129	0.453	0.312
Handgrip	0.589	0.577	0.449	0.282	-0.056	0.147	1.000	0.622	0.027	0.222
Back-leg	0.450	0.429	0.352	0.280	0.074	0.129	0.622	1.000	0.223	0.324
Push-ups	-0.303	-0.263	-0.244	0.295	0.174	0.453	0.027	0.223	1.000	0.386
Sit-ups	-0.052	0.100	-0.104	0.376	0.042	0.312	0.222	0.324	0.386	1.000

Note. SBJ -standing broad jump; MBT – medicine ball throw; BAH – bent-arm hang; Back-leg – Pulling back-leg dynamometry.

Table 2 shows the results of the Spearman correlation of the whole sample. A strong correlation was found between the variables handgrip and MBT (0.637), back-leg and handgrip (0.629), back-leg and MBT (0.610). Moderate correlations were found for SBJ and MBT (0.464), push-ups, and BAH (0.424). Otherwise, there was a weak or very weak correlation. When anthropometry and muscle testing were analysed, the strongest correlations were identified between handgrip and height and weight (0.589 and 0.576, respectively), and weight and MBT (0.514). The other relationships were weak or very weak and for the push-ups, and BAH tests a negative trend was reported. In the performance of girls, a strong correlation was found between MBT and handgrip and back-leg, respectively (0.606, 0.617), and comparably for handgrip and back-leg (0.592). In boys, a strong correlation was identified between back-leg and handgrip (0.621). Moderate correlations were found between the following variables: SBJ and BAH (0.430); BAH and push-ups (0.452).

Table 3. Correlation results between muscular fitness tests and anthropometry in age groups.

	Weight (kg)	Height (cm)	BMI	SBJ (cm)	MBT (m)	BAH (s)	Handgrip (kg)	Back-leg (kg)	Push-ups (reps)	Sit-ups (reps)
2012										
Weight	1.000	0.546	0.911	-0.189	0.305	-0.359	0.500	0.355	-0.278	-0.212
Height	0.546	1.000	0.162	0.181	0.355	-0.175	0.414	0.303	-0.148	0.044
BMI	0.911	0.162	1.000	-0.311	0.199	-0.353	0.389	0.279	-0.257	-0.265
SBJ	-0.189	0.181	-0.311	1.000	0.472	0.315	0.285	0.284	0.309	0.360
MBT	0.305	0.355	0.199	0.472	1.000	0.018	0.420	0.425	0.128	0.128
BAH	-0.359	-0.175	-0.353	0.315	0.018	1.000	-0.044	-0.028	0.268	0.320
Handgrip	0.500	0.414	0.389	0.285	0.420	-0.044	1.000	0.637	0.003	0.062
Back-leg	0.355	0.303	0.279	0.284	0.425	-0.028	0.637	1.000	0.216	0.066
Push-ups	-0.278	-0.148	-0.257	0.309	0.128	0.268	0.003	0.216	1.000	0.346
Sit-ups	-0.212	0.044	-0.265	0.360	0.128	0.320	0.062	0.066	0.346	1.000
2011										
Weight	1.000	0.649	0.920	-0.199	0.463	-0.314	0.506	0.453	-0.197	-0.124
Height	0.649	1.000	0.310	0.044	0.465	-0.111	0.523	0.477	-0.041	0.181
BMI	0.920	0.310	1.000	-0.271	0.352	-0.349	0.362	0.330	-0.230	-0.240
SBJ	-0.199	0.044	-0.271	1.000	0.360	0.456	0.100	0.174	0.373	0.330
MBT	0.463	0.465	0.352	0.360	1.000	0.138	0.507	0.523	0.176	0.227
BAH	-0.314	-0.111	-0.349	0.456	0.138	1.000	0.113	0.104	0.534	0.319
Handgrip	0.506	0.523	0.362	0.100	0.507	0.113	1.000	0.480	0.167	0.176
Back-leg	0.453	0.477	0.330	0.174	0.523	0.104	0.480	1.000	0.281	0.333
Push-ups	-0.197	-0.041	-0.230	0.373	0.176	0.534	0.167	0.281	1.000	0.461
Sit-ups	-0.124	0.181	-0.240	0.330	0.227	0.319	0.176	0.333	0.461	1.000
2010										
Weight	1.000	0.615	0.906	-0.244	0.409	-0.336	0.484	0.316	-0.334	-0.100
Height	0.615	1.000	0.241	-0.001	0.353	-0.219	0.456	0.235	-0.276	0.002
BMI	0.906	0.241	1.000	-0.265	0.332	-0.296	0.373	0.279	-0.265	-0.119
SBJ	-0.244	-0.001	-0.265	1.000	0.406	0.393	0.314	0.323	0.381	0.339
MBT	0.409	0.353	0.332	0.406	1.000	0.201	0.616	0.586	0.177	0.259
BAH	-0.336	-0.219	-0.296	0.393	0.201	1.000	0.151	0.193	0.457	0.302
Handgrip	0.484	0.456	0.373	0.314	0.616	0.151	1.000	0.601	0.101	0.205
Back-leg	0.316	0.235	0.279	0.323	0.586	0.193	0.601	1.000	0.318	0.304
Push-ups	-0.334	-0.276	-0.265	0.381	0.177	0.457	0.101	0.318	1.000	0.404
Sit-ups	-0.100	0.002	-0.119	0.339	0.259	0.302	0.205	0.304	0.404	1.000

Note. SBJ -standing broad jump; MBT – medicine ball throw; BAH – bent-arm hang; Back-leg – Pulling back-leg dynamometry.

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Relationships between variables were also found between age groups (Table 3). Situations, where at least a moderate relationship was identified, are described further. For the 9-10 years group, strong correlations were found between handgrip and back-leg (0.600), MBT and dynamometry (0.616 and 0.585, respectively); moderate relationships were found between push-ups and BAH (0.457) and sit-ups (0.404). For both boys and girls, the strongest relationships were found between MBT and dynamometry, and SBJ, respectively. Boys also showed a significant relationship between push-ups and BAH.

The entire group of 10-11 years showed r values > 0.4 in the following cases: push-ups and BAH (0.534), MBT and dynamometry (0.506 and 0.522, respectively), handgrip and back-leg (0.479), and push-ups and SBJ (0.455). Girls showed a more significant relationship for MBT and dynamometry (0.587 and 0.485, respectively), and BAH and SBJ (0.564). For boys, the tests (> 0.4) were: MBT and dynamometry, BAH and push-ups.

The 11-12 year group showed a strong correlation between handgrip and back-leg (0.637), moderate for MBT and handgrip, with weak or very weak correlations in all other cases. For both girls and boys, there was a strong correlation between handgrip and back-leg.

DISCUSSION

The primary goal of our study was to evaluate and correlate various muscular fitness tests with anthropometric measurements among Czech children. Out of the seven tests administered, only handgrip with MBT, handgrip with back-leg, and MBT with back-leg demonstrated a strong relationship (r > 0.6). The BAH and push-ups exhibited a moderate correlation. In most instances, correlations were weak or very weak (r > 0.4). This pattern was consistent when examining the relationship between anthropometric variables and muscle tests, with height and weight showing moderate correlations with handgrip and MBT tests. While gender and age group analyses yielded some robust correlations for dynamometry, MBT, and anthropometric measurements, these were not universally observed across all groups.

Previous research has indicated similar trends in the assessment of relative strength, particularly in upper body strength (Beunen & Thomis, 2000; Chen et al., 2018; Milliken et al., 2008). Our findings, however, revealed only moderate correlations, indicating that while there is a common trend, it is not particularly strong. The results suggest that each test of relative strength—including push-ups, BAH, and sit-ups—provides unique insights and does not independently or adequately predict upper body strength. Consequently, reliance on a single test for assessment could lead to misleading conclusions.

The use of the pulling back-leg dynamometer is an innovative approach, offering an alternative to the classical deadlift, which is more technically demanding (Schlegel et al., 2022). This type of pulling strength (isometric midthigh pull) correlates strongly with the 1 RM deadlift (De Witt et al., 2018). Although not as prevalent in children, testing one-repetition maximum (1 RM) has been shown to be effective and safe (Faigenbaum et al., 2003). The absolute strength parameter shows a strong association (r ≥ 0.6) with anthropometric measurements in adult population (Ferland et al., 2020). We can only partially confirm this phenomenon in child population. Before the onset of puberty, there is a marked difference in body composition, amount of muscle mass, and muscle fibre composition (Ervin et al., 2014; Esbjörnsson et al., 2021), which likely influences this relationship.

The study observed a consistent trend where dynamometry measurements strongly correlated with the MBT test, suggesting that the 3 kg medicine ball throw could serve as a predictive marker of absolute strength and a potential substitute for more complex dynamometry in field assessments. However, this hypothesis requires further investigation for validation. The expected strong correlations between handgrip strength, relative strength (push-ups, BAH), and absolute strength did not materialize as anticipated, which contrasts with other studies (Pate et al., 1993; Wind et al., 2010). Although both categories represent a valid tool of testing muscle strength (Baumgartner et al., 2002; Molenaar et al., 2008), no significant association was found here. These discrepancies highlight the necessity for distinct assessments for relative and absolute strength.

When analysed by age, the study did not consistently observe strong correlations between tests or anthropometric measurements. This suggests that a finer stratification by year or even shorter intervals may be more appropriate for analysing physical fitness parameters. Notably, significant changes in physical fitness can occur over quarters, as shown by Veldhuizen et al. (2015). Thus, we recommend yearly evaluations to yield more precise outcomes. This approach is particularly relevant for larger cohorts where biological age significantly influences data interpretation (Gómez-Campos et al., 2018).

Height and weight were not strongly correlated with relative strength (BAH, push-ups, sit-ups) in prepubertal children. While higher weight often corresponds to poorer performance (Castro-Piñero et al., 2009; Ervin et al., 2014; Martínez-López et al., 2018), our study identified only a weak negative correlation, suggesting that this relationship may strengthen during adolescence or adulthood, as supported by other research (Markovic & Jaric, 2004).

The simultaneous assessment of dynamic and relative strength is common in test batteries; however, our results indicate that these dimensions of strength are only weakly related and should be tested independently. Furthermore, SBJ remains an isolated measure of lower body dynamic strength, with no substantial connection to absolute strength. Although SBJ is a reliable predictor of dynamic strength or speed performance, its correlation to overall health or fitness in adults remains ambiguous (Rodriguez et al., 2021; Thomas et al., 2020).

A limitation of our study was the non-standardized age grouping, as no gradual increase in handgrip strength was observed between the 9-10 and 11-12 age groups. Additionally, the presence of zero scores on the push-ups and BAH tests in 12-15% of the children could have skewed the data analysis, suggesting the need for alternative assessments in future research.

CONCLUSION

Assessing muscular fitness is a crucial element of evaluating health and wellness. Our study has established robust correlations specifically between dynamometry and MBT. Furthermore, we found significant but varying degrees of correlation between anthropometric measurements and specific tests such as handgrip and back-leg, with height and weight showing minimal to negative correlations with bodyweight tests like the BAH. The majority of correlations, particularly when accounting for age differences, were weak, suggesting that distinct muscle strength types and their respective tests largely operate independently and cannot be reliably interchanged. Consequently, to gain a comprehensive understanding of muscular fitness, it is essential to utilize a combination of tests, carefully selected for their predictive accuracy and relevance.

AUTHOR CONTRIBUTIONS

Petr Schlegel: conceptualization, methodology, writing – review and editing, supervision. Adam Křehký: formal analysis, data analysis.

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