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ANALYSIS OF THE ASSOCIATIONS BETWEEN DIRECTLY MEASURED PHYSICAL ACTIVITY AND PHYSICAL FITNESS IN PREADOLESCENTS: CONTEXTUALIZING THE INFLUENCE OF URBAN VS. RURAL LIVING ENVIRONMENTS

ANALIZA POVEZAV MED NEPOSREDNO IZMERJENO TELESNO DEJAVNOSTJO IN TELESNO ZMOGLJIVOSTJO PRI PREDMLADOSTNIKIH: KONTEKSTUALIZACIJA VPLIVA URBANEGA IN PODEŽELSKEGA ŽIVLJENJSKEGA OKOLJA

ABSTRACT

There is an evident lack of investigations in which associations between physical activity (PA) and physical fitness (PF) were simultaneously evaluated in urban- and rural-living children. This study aimed to investigate the gender-specific associations between directly measured PA and various measures of PF in urban and rural children. The participants were 126 children aged 9--11 years (49 girls) from elementary schools in southern Croatia. In addition to age, gender (male, female), living environment (urban, rural), and anthropometrics (body mass, height, and BMI), the variables included accelerometer-derived PA indices (obtained by GeneActic triaxial accelerometers) and PF tests (evaluating jumping power capacity, upper-body- and abdominal-strength, mobility, flexibility, and aerobic endurance). Vigorous PA was related to jumping power, upper body strength and aerobic endurance in urban boys (Pearson's R = 0.34–0.36, $p < 0.05$) and with upper body strength in rural boys (R = 0.41, $p < 0.05$). The number of steps performed daily was associated with jumping power in urban girls (R = 0.42, $p < 0.05$) and with abdominal strength in rural girls (R = 0.42, $p < 0.05$). Vigorous PA was associated with jumping power (R = 0.44, $p < 0.05$), upper body strength (R = 0.39, $p < 0.05$), and aerobic endurance (R = 0.39, $p < 0.05$) in urban girls and with jumping power (R = 0.61, $p < 0.05$), abdominal strength (R = 0.45, $p < 0.05$), and aerobic endurance (R = 0.40, $p < 0.05$) in rural girls. Socioeconomic differences, cultural norms, and parental views on PA in urban and rural communities may explain the varying relationships between PA and PF observed in urban and rural boys. Further longitudinal studies are needed to establish clear cause–effect relationships between PA and PF.

Key words: prepuberty, sociodemographic factors, motor capacities, cardiovascular endurance, anthropometrics

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IZVLEČEK

Obstaja pomanjkanje raziskav, v katerih bi hkrati preučevali povezave med telesno dejavnostjo (TD) in telesno zmogljivostjo (TZ) pri otrocih, ki živijo v urbanih in podeželskih okoljih. Cilj te študije je bil raziskati spolno specifične povezave med neposredno izmerjeno TD in različnimi merami TZ pri otrocih iz urbanih in podeželskih okolij. V raziskavi je sodelovalo 126 otrok, starih 9–11 let (49 deklic), iz osnovnih šol v južni Hrvaški. Poleg starosti, spola (moški, ženski), okolja bivanja (urbano, podeželsko) in antropometričnih mer (telesna masa, telesna višina in ITM) so bile vključene tudi spremenljivke, pridobljene z merjenjem TD s triosnimi merilniki pospeška GeneActiv, ter testi TZ (ocenjevanje eksplozivne moči nog, moči zgornjega dela telesa in mišic trupa, gibljivosti, mobilnosti in srčno-dihalne vzdržljivosti). Intenzivna telesna dejavnost je bila povezana z eksplozivno močjo nog, močjo zgornjega dela telesa in srčno-dihalno vzdržljivostjo pri urbanih dečkih (Pearsonov R = 0,34–0,36, $p < 0,05$) ter z močjo zgornjega dela telesa pri podeželskih dečkih (R = 0,41, $p < 0,05$). Število korakov na dan je bilo povezano z eksplozivno močjo nog pri urbanih deklicah (R = 0,42, $p < 0,05$) in močjo trupa pri podeželskih deklicah (R = 0,42, $p < 0,05$). Intenzivna TD je bila pri urbanih deklicah povezana z eksplozivno močjo nog (R = 0,44, $p < 0,05$), močjo zgornjega dela telesa (R = 0,39, $p < 0,05$) in srčno-dihalno vzdržljivostjo (R = 0,39, $p < 0,05$), pri podeželskih deklicah pa z eksplozivno močjo nog (R = 0,61, $p < 0,05$), močjo trupa (R = 0,45, $p < 0,05$) in srčno-dihalno vzdržljivostjo (R = 0,40, $p < 0,05$). Socioekonomske razlike, kulturne norme in stališča staršev do TD v urbanih in podeželskih skupnostih lahko pojasnijo razlike v povezanosti TD in TZ pri urbanih in podeželskih dečkih. Za vzpostavitev jasnih vzročnih povezav med TD in TZ bodo potrebne nadaljnje longitudinalne raziskave.

Ključne besede: predpuberteta, socioekonomski faktorji, gibalne sposobnosti, srčno-dihalna vzdržljivost, antropometrija

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INTRODUCTION

Physical activity (PA) encompasses any bodily movement produced by skeletal muscles that results in energy expenditure (Caspersen, Powell, & Christenson, 1985; Zlatar et al., 2015). Higher levels of PA during childhood are associated with children's current health and well-being, reducing the risk of developing chronic diseases such as obesity, type 2 diabetes, and cardiovascular disease later in life. Furthermore, regular PA promotes healthy bone development, improves motor skills, and contributes to cognitive development and mental well-being in children (Sember & Premelč, 2024). For example, research by Ortega et al. (2008) highlights that aerobic fitness, achieved through sustained PA, is a key indicator of cardiovascular health and is inversely associated with obesity risk in children (Ortega, Ruiz, Castillo, & Sjöström, 2008). Similarly, PA involving strength-building exercises promotes musculoskeletal development and reduces the likelihood of injuries (Faigenbaum et al., 2009). Therefore, encouraging and facilitating regular PA from an early age is vital for fostering lifelong health and well-being (Bloch, Ribeiro, Santos, & Pizarro, 2024; Wallhead & Buckworth, 2004).

Physical fitness (PF) is a set of attributes related to the ability to perform everyday activities, and regular PA is considered to be a cornerstone for improving and maintaining overall PF in children (Caspersen et al., 1985). It is generally accepted that children who engage in higher levels of PA demonstrate superior performance in PF-measures, such as aerobic capacity, muscular strength, and flexibility. Studies have reported an association between greater PA and better PF in preschoolers (Haugland, Nilsen, Okely, Aadland, & Aadland, 2023; Serrano-Gallén, Arias-Palencia, González-Víllora, Gil-López, & Solera-Martínez, 2022). Investigations on adolescents revealed significant associations between higher PA and lower body fatness, better cardiovascular fitness, and better muscular fitness, which was evident even during the COVID-19-129 pandemic (De Baere, Philippaerts, De Martelaer, & Lefevre, 2016; Sunda, Gilic, Peric, Jurcev Savicevic, & Sekulic, 2021). However, not all studies have confirmed positive correlations between PA and PF. For example, a recent Croatian study did not report any significant correlation between indirectly measured PA and PF indices in preadolescents (Rajkovic Vuletic et al., 2024).

Sociodemographic factors, such as the living environment, particularly the distinction between urban and rural settings, can significantly influence children's PA patterns (Tian et al., 2021; Zenic et al., 2020). Urban environments offer more opportunities for involvement in organized sports, which is currently known to be the most important factor contributing to overall PA in children (Zenic et al., 2020). In contrast, the urban environment often presents challenges such as limited green spaces, traffic congestion, and safety concerns, potentially restricting children's opportunities for outdoor play and active transportation. In contrast, rural environments may offer more access to natural spaces, promoting activities such as hiking, cycling, and unstructured outdoor play. However, rural areas may also face barriers such as limited access to organized sports facilities and programs, as well as greater distances to travel for participation in structured activities (Carlman & Högman, 2024). Furthermore, socioeconomic factors (i.e., parental attitudes toward PA, socioeconomic status of the family), and cultural norms within urban and rural communities can also contribute to variations in children's activity levels. Investigating these environmental influences is essential for developing targeted interventions to promote PA and address disparities in PF among children residing in different settings. Understanding these nuances could help create more equitable opportunities for all children to engage in regular PA and achieve optimal health.

Although correlations between PA and PF in children are frequently studied, investigations in which such associations were specifically compared between rural and urban children are lacking. Specifically, there is an evident lack of research where correlations between PA and PF were studied simultaneously in both living environments via the same instruments and protocols. Comparing the correlation between PA and PF in urban versus rural children is crucial for understanding how sociodemographic and environmental factors shape outcomes. In other words, the type of PA available and typically performed can differ significantly between urban and rural settings (Zenic et al., 2020). These differences in PA patterns could lead to variations in the specific components of PF developed (e.g., aerobic endurance vs. muscular strength). Furthermore, the availability of sports facilities and programs, which are often limited in rural areas, can influence the intensity and frequency of structured exercise. Examining the correlations between PA and PF simultaneously in urban and rural children could help identify potential disparities in both PA and PF and inform targeted interventions to promote specific types of activities that address unique challenges in urban and rural environments. Ultimately, this comparison can contribute to the development of more effective strategies for improving children's PF and well-being regardless of their place of residence.

This study aimed to investigate the gender-specific associations between directly measured PA and various indices of PF in urban and rural children. To achieve this goal, we assessed PA by accelerometers, and evaluated PF in children residing in both urban and rural environments and conducted environment-specific and gender-specific analyses to determine the associations between PA and PF. Our initial hypothesis proposed that PA would be similarly associated with PF indices in preadolescent children, regardless of their living environment or gender.

METHODS

Participants

This study involved 126 children aged 9-11 years (49 girls) from elementary schools across Split Dalmatia County, Croatia, residing in urban (n = 75), and rural communities (n = 51). All the participants attended regular school and physical education classes, with some also participating in extracurricular sports. Prior to the study, school authorities were informed about the idea of the study, and school principals arranged parent meetings. Researchers explained the study's purpose, procedures, potential risks and benefits and obtained written consent from almost 90% of the parents present. Children were included if they regularly participated in physical education, were healthy one week prior, and remained healthy throughout the study. Children with motor/functional impairments, health issues preventing physical education participation, or injuries/illnesses one week before or during the study were not included. Initially, 162 children were recruited, but technical issues (i.e., problems with accelerometer data, excessive nonwear time), inconsistent data, injuries, and illnesses reduced the final sample to 126. The study was approved by the Ethical Board of Faculty of Kinesiology, University of Zagreb.

Variables

In addition to living environment (urban vs. rural), age (in years), and gender (male vs. female; collected on the basis of school records), in this study, we obtained data on PA, anthropometrics, and PF.

GeneActiv triaxial accelerometers were used for direct measurement of the PAs of the participants over a seven-day period (Activinsights Ltd., Cambs, United Kingdom). The GeneActiv is a small (43×40×13 mm), lightweight (16 g), waterproof device that collects raw acceleration data in the range of ±8 g. The device was validated for children aged 7-14 years. In this study, accelerometers were worn on the wrist, which is generally preferred when children are evaluated. The participants were instructed that the devices were waterproof and worn continuously, including while sleeping, swimming, and showering, which allowed them to obtain a complete picture of their activity patterns. After the wearing period, devices were connected to the computer, and raw acceleration data were downloaded via specific software. The same software data were cleaned, and nonwear time periods were removed. Participants worn devices during the two school days (Thursday and Friday), and whole weekend (Saturday and Sunday). In this study we observed PA of one day (averaged Thursday and Friday data multiplied by five (resulting in average value for school days Monday - Friday), summarized with Saturday and Sunday data (resulting in whole week PA), all divided by seven (resulting in average per day)). The participants were asked to only remove the accelerometer during contact sports when the device could be a risk of injury, otherwise that the device should be worn on their non-dominant wrist 24 h/day. The accelerometers were set to sample at frequency of 30 Hz. The PA variables observed in this study were based on accelerometer records and included the number of steps performed daily, sedentary time, light PA, moderate PA, and vigorous PA.

Anthropometrics included body height, mass and body mass index. Body height was measured with an altimeter, and body mass was measured with a digital diagnostic scale (Tanita BC 418 scale; serial number 15010067, 2015), both following standardized procedures. Body mass index (BMI) was calculated by dividing body mass (in kg) by the squared body height (in meters).

For the purpose of evaluating PF, we used tests included in the FitnessGram battery (Meredith & Welk, 2010), with the addition of one test of power capacity. The 15-m multilevel running test (Beep-test) was used to assess aerobic endurance (cardiovascular endurance). The test consists of 21 or more levels of 7 or more intervals of running segments of 15 m. Participants run from one end to the other of a segment marked with cones and must touch the line when the buzzer sounds. At the sound of the beep, they turn and run back to the other end. The participants continue to do this until they reach the line before two beeps. The goal is to cross as many levels as possible, and the result is expressed numerically in levels. The sit-up test (Sit-ups) was used to assess abdominal muscular strength and endurance. The test is performed by having the participant lift the torso as many times as possible, up to a maximum of 75. The result is the maximum number of correctly performed torso lifts. The trunk lift test (Trunk lift) was used to assess torso extensor strength and flexibility. On cue, the participant independently raises the cervical and thoracic parts of the spine in a controlled manner to their maximum, with the head in a neutral position in line with the spine. The push-up test (Push-ups) was used to assess upper body strength and endurance. The test is performed so that the participant takes a pronated position on the mat with the palms under the shoulders, fingers extended, legs extended and parallel, and feet slightly apart, resting on the toes. The participant pushes off the mat with their hands until their arms are extended, keeping their legs and back straight. The participant then lowers their body using their arms until their elbows are bent at 90 degrees and their upper arms are parallel to the floor. The result is the maximum number of correctly performed push-ups. The sit-and-reach test (Sit-and-reach) was used to assess the flexibility of the lower back and hamstring muscles. The participant sits on the floor with their legs extended straight ahead, feet shoulder width apart, and positioned against the box or measuring device. With their palms down and fingers pointing forward, the individual reaches forward along the measuring device as far as possible, holding the position for at least two seconds. Three trials are performed, and the average score is used as the final result. A standing long jump (long jump) was used to assess jumping performance/power capacity. The test is performed so that the participant stands behind the starting mark and jumps from the place with bare feet as far as possible. A standardized measurement mat was used (ELAN, Begunje, Slovenia). The results were measured in centimeters, which was the best of three attempts.

Statistics

The Kolmogorov–Smirnov test was used to confirm that the data followed a normal distribution, a key assumption for later statistical tests. Means and standard deviations were calculated to provide a basic overview of the data characteristics. Independent samples t tests were used to explore potential differences in the study variables between urban and rural children, stratified by gender.

Pearson's correlation coefficients were calculated to assess the relationships between variables, and correlations were interpreted on a scale ranging from 0.00–0.19 (very weak), 0.20–0.39 (weak), 0.40–0.69 (moderate), 0.70–0.89 (strong), and 0.90–1.00 (very strong), providing a clear indication of the strength of the associations. The correlations were stratified by living community and gender.

Statistica (Tibco, Inc., Palo Alto, CA, USA) was used for all calculations, and a p value of 0.05 was applied.

RESULTS

Descriptive statistics and t test differences between urban and rural boys are presented in Table 1. Compared with rural boys, urban boys were taller (t test = 4.11, $p < 0.001$), heavier (t test = 2.21, $p < 0.05$), and performed better in the flexibility test (t test = 2.37, $p < 0.05$). Rural boys performed better in terms of the strength capacity of the upper body (t test = 2.43, $p < 0.05$).

Table 1. Descriptive statistics and t test differences for the study variables between urban and rural boys.

	Urban (n = 44)		**Rural (n = 33)**		**t test**	
	Mean	**Std.Dev.**	**Mean**	**Std.Dev.**	**t value**	**p**
Body height (cm)	146.4	7.10	140.1	7.10	4.11	0.001
Body mass (kg)	39.0	8.90	34.7	8.99	2.21	0.03
BMI (kg/m^2)	18.1	3.30	17.4	3.27	0.94	0.35
Broad jump (cm)	142.1	25.05	143.5	17.60	-0.27	0.79
Push-ups (rep)	11.4	8.70	16.1	9.78	-2.43	0.02
Sit-ups (rep)	16.9	13.69	11.8	7.99	1.98	0.05
Trunk lift (cm)	20.0	11.65	18.2	5.54	0.85	0.40
Sit-and-reach (cm)	41.6	9.09	36.8	9.49	2.37	0.02
Beep-test (level)	8.1	2.56	8.9	2.41	-1.39	0.17
Steps performed (count)	14640	3784	12900	5338	1.65	0.10
Sedentary time (min/day)	438.0	128.61	422.3	66.69	0.62	0.53
Light physical activity (min/day)	335.4	130.78	342.7	88.31	-0.27	0.79
Moderate physical activity (min/day)	185.3	51.22	172.1	46.38	1.14	0.26
Vigorous physical activity (min/day)	41.0	24.32	58.2	35.34	-2.49	0.01

When girls were compared in terms of the study variables, significant differences in body height were found, with urban girls being taller than rural girls (t test = 2.59, $p < 0.01$), upper body strength and abdominal strength (t test = 2.27 and 2.25, $p < 0.05$; urban girls performed better in both capacities) (Table 2).

Table 2. Descriptive statistics and t test differences for the study variables between urban and rural girls.

	Urban (n = 31)		Rural (n = 18)		t test	
	Mean	Std.Dev.	Mean	Std.Dev.	t value	p
Body height (cm)	144.0	6.93	139.2	6.66	2.59	0.01
Body mass (kg)	38.5	14.31	34.5	8.25	1.17	0.25
BMI (kg)/m^2)	17.6	3.83	17.6	2.93	-0.06	0.95
Broad jump (cm)	131.6	40.35	132.6	18.53	-0.10	0.92
Push-ups (rep)	11.6	10.58	5.9	5.40	2.27	0.03
Sit-ups (rep)	20.5	14.05	11.2	7.67	2.75	0.01
Trunk lift (cm)	21.7	13.02	18.2	3.83	1.19	0.24
Sit-and-reach (cm)	50.3	17.16	44.5	7.73	1.45	0.15
Beep-test (level)	6.7	2.75	6.8	1.94	-0.10	0.92
Steps performed (count)	11816	3468	12466	3669	-0.61	0.54
Sedentary time (min/day)	438.6	108.00	432.0	76.93	0.22	0.83
Light physical activity (min/day)	332.2	88.69	368.3	88.87	-1.35	0.18
Moderate physical activity (min/day)	180.2	48.91	179.5	39.64	0.05	0.96
Vigorous physical activity (min/day)	23.2	14.44	28.4	14.59	-1.19	0.24

The correlations between the PA variables and PF indices among urban and rural boys are presented in Figure 1. The body height, mass, and BMI were generally negatively correlated with PA variables, particularly with vigorous PA, with somewhat stronger correlations between anthropometrics and vigorous PA in rural boys. Furthermore, the number of steps was positively correlated with broad jump (weak correlation), push-ups (weak correlation) and Beep tests (moderate correlation) in rural boys and positively correlated with the sit-and-reach test in rural boys (weak correlation). Vigorous PA was positively correlated with broad jump, push-ups, and beep test in urban boys (weak correlations) and with push-ups in rural boys (moderate correlation).

In urban girls, the number of steps was negatively correlated with BMI (weak correlation) and positively correlated with broad jump (moderate correlation). Furthermore, vigorous PA was negatively correlated with body mass (moderate correlation) and BMI (moderate correlation) and positively correlated with broad jump (moderate correlation), push-ups (weak correlation), and the Beep test (weak correlation). In rural girls, the number of steps was positively correlated with the number of sit-ups (moderate correlation), whereas vigorous PA was positively correlated with a broad jump (moderate correlation) and a Beep test (moderate correlation) (Figure 2).

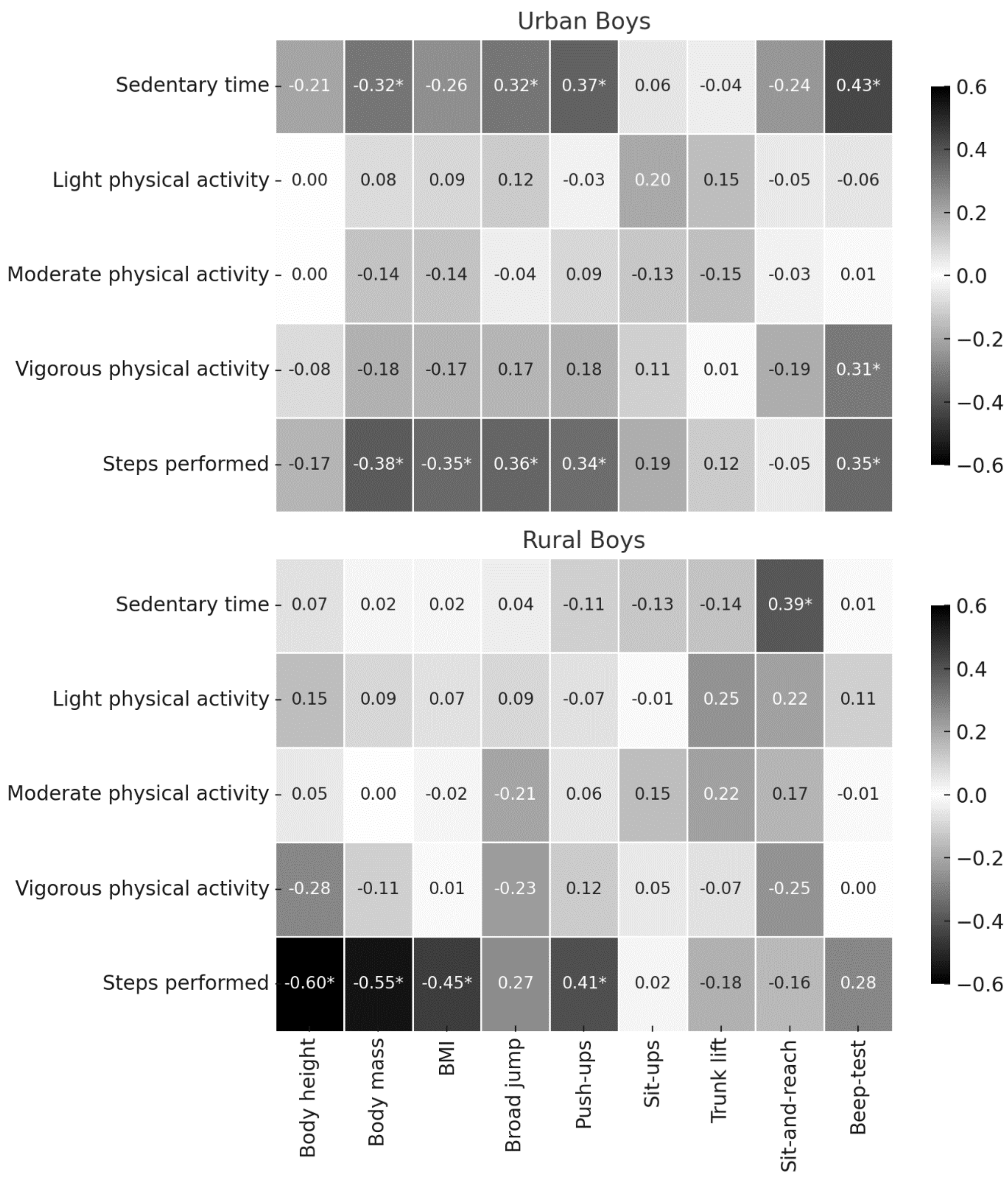

Figure 1. Numerical values of the correlation coefficients and heatmap presentation of the associations between physical activity indices with anthropometrics, and physical fitness variables for urban and rural boys (* indicates significance of $p < 0.05$).

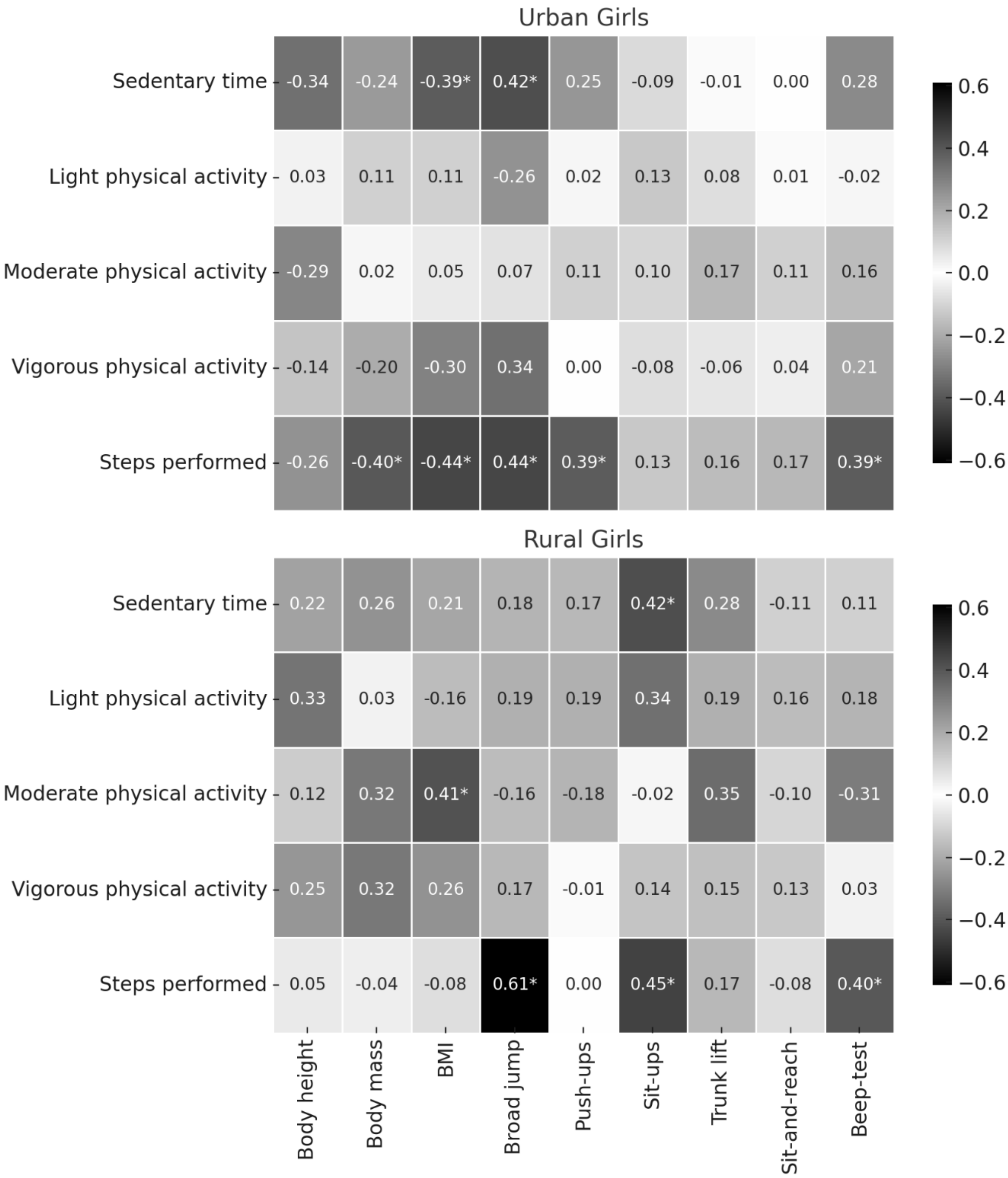

Figure 2. Numerical values of the correlation coefficients and heatmap presentation of the associations between physical activity indices with anthropometrics, and physical fitness variables for urban and rural girls (* indicates significance of $p < 0.05$).

DISCUSSION

There are several important findings of this study. First, the correlations between PA and PF were weak to moderate. Next, the associations between PF and PA were stronger in urban boys than in rural boys. When girls were observed, no evident differences in the correlations between PA and PF were detected between urban and rural girls. Therefore, our initial study hypothesis can be partially accepted.

As stated in the introduction, the associations between PF and PA in children have been studied globally, but despite the general opinion that PA and PF should be strongly correlated, studies performed thus far have mostly reported moderate correlations between PA and PF (De Baere et al., 2016; Sunda et al., 2021). Moreover, some reports did not even find a significant correlation between PF and PA (Rajkovic Vuletic et al., 2024). The explanations varied and included (i) the problem of subjective measurement of the PA (i.e., studies often use questionnaires for evaluating PA), (ii) a lack of consistency in PA evaluation (i.e., even when PA was directly measured, participants were tested during different periods of years and weather conditions were not identical), and (iii) the influence of confounding factors (i.e., various living environments).

Our results showing weak to moderate correlations between directly measured PA and PF indices are in line with previous research in which similar magnitudes of associations were reported (De Baere et al., 2016; Sunda et al., 2021). However, it is evident that of all the PA intensities studied, vigorous PA (and number of performed steps as a consequence of vigorous PA) most significantly contributes to PF status in preadolescents from southern Croatia. The possible background of those findings is discussed from both physiological and sociocultural perspectives.

From a physiological standpoint, vigorous PA is crucial for the development of PF in children because of its impact on several key systems. First, it stimulates muscle growth and strength development by overloading muscle fibers, leading to adaptations such as hypertrophy and improved neuromuscular coordination. This type of activity also significantly improves aerobic endurance by strengthening the cardiovascular system and increasing its efficiency. Hormonal changes triggered by PA, such as the release of growth hormone, further contribute to PF development. Neurological benefits also arise, as repeated intensive physical engagement improves motor skills and coordination by improving neurotransmissions, directly contributing to different PF indices (Gericke, Pienaar, Gerber, & Monyeki, 2024; Rowland, 1996).

In addition to physiological benefits, sociocultural factors also contribute to the importance of vigorous PA for children's PF. In brief, it is well known that participation in sports and active play is encouraged and seen as a positive social outlet in many cultures, including Croatia, where this study was conducted (Sekulic, Blazevic, Gilic, Kvesic, & Zenic, 2020). These activities often involve bursts of vigorous movement, fostering teamwork, social skills, and a sense of belonging. Moreover, societal norms and parental involvement play a significant role in shaping children's activity levels. Parents who encourage and support their children's participation in vigorous PA, such as organized sports or outdoor play, contribute to regular participation, and this consistency naturally contributes to the development of PF. Although at this moment we are not able to define which of these factors was the most influential, the authors believe that the combination of these psychological and sociocultural factors contributed to our findings as well.

Our results highlighted differences in the correlations between PA and PF between urban and rural boys, with stronger correlations in urban boys. The first factor that could explain those results is participation in organized sports. In general, urban living environments provide more opportunities for the active involvement of children in different sports, and studies have regularly confirmed greater sport participation in urban children, particularly boys (Zenic et al., 2020). This greater degree of participation in sports among urban children may have contributed to a stronger association between PA and PF, even in the boys studied here, due to the structured and intense nature of these activities.

Specifically, organized sports often involve regular training sessions, coaching, and a focus on skill development, which can lead to greater improvements in various components of PF, such as aerobic endurance, muscular strength, and power (Tahira, 2021). Moreover, sports participation provides opportunities for children to engage in vigorous PA in a social and supportive environment, which can further enhance their motivation and adherence to PA (Phillips & Young, 2009). This combination of structured training and social support can lead to more significant improvements in PF among urban boys who participate in sports, resulting in a stronger correlation between PA and PF.

Supportively, our results revealed the strongest correlations between accelerometer-derived PA and those PF indices which are directly influenced by systematic and targeted exercise regimens, and intensive PA (i.e., power, strength, and aerobic endurance). In contrast, the correlations between the PA variables and flexibility/mobility were not significant. Although these findings may seem somewhat contradictory, they are easily explained by the physiological background and specificity of the physical exercise needed for improvement in this PF-variable. In short, flexibility training focuses on specific exercises and techniques to increase the range of motion around a joint. These methods often involve slow, controlled movements and stretching for an extended period (Alter, 2004). Vigorous PA, on the other hand, typically involves rapid and forceful movements that may not effectively target the muscle lengthening and relaxation required for improved flexibility and are therefore not directly related to improvements in flexibility.

One could argue that the rural environment provides more opportunities for PA (note that rural boys exhibit greater vigorous PA than urban boys do), and therefore, there is no reason for the lower association between PA and PF in rural boys. However, while rural environments may offer children ample opportunities for free play, this does not necessarily directly translate to significant improvements in aspects of PF (Özdirenç, Özcan, Akin, & Gelecek, 2005). Specifically, free play often involves unstructured activities with varying levels of intensity and may not consistently challenge children's cardiovascular system or musculoskeletal strength to the extent required for optimal fitness development. Furthermore, free play may not always provide the targeted exercises and structured routines necessary for developing specific components of PF. For example, exploring natural terrains can contribute to overall PA, but these activities may not provide the same benefits as structured programs that incorporate specific exercises and progressions designed to improve PF indices. Therefore, despite the eventually high levels, the PA in rural environments may not be targeted with respect to its adaptational specificity to ensure the comprehensive development of PF, resulting in a lower association between PA and PF in rural boys.

In contrast to boys, where the correlation between PA and PF was stronger in urban-, than in rural-residing boys, the associations between PA and PF in girls were similar across living communities. The most important factor was similar vigorous PA in both groups of girls (note that vigorous PA was not different between living communities among girls). As previously discussed, changes in PF occur mostly as a result of vigorous PA (Rowland, 1996). Although there is no doubt that urban girls are more likely to participate in organized sports, which involve intense bursts of activity and structured drills, rural girls might engage in activities such as free play or help with farm chores, which can also be physically demanding and require sustained effort. In other words, even though urban girls might have access to more structured PA programs, the actual intensity and duration of these activities might not differ significantly from the unstructured play of rural girls. Both types of activities, whether structured or unstructured, can improve aerobic endurance if they involve sustained periods of elevated heart rate and breathing. With regard to power capacity, activities such as climbing, jumping, lifting, and running can contribute to development in both urban and rural girls, even if the specific exercises differ. Therefore, the similar vigorous PA levels of urban and rural girls could ultimately contribute to similar correlations between PA and PF.

The question that arises is why greater participation in sports in urban girls was not translated into higher vigorous PA, and better PF, as was the case for boys. Indeed, although it could be expected, it is probable that the nature and type of sports girls involved (e.g., dance, swimming) did not directly increase vigorous PA, and improve the PF indices we studied here (strength, power, aerobic endurance tested by running test) (Rowland, 1996). As a result, higher sport participation and structured PA in urban girls did not result in a stronger correlation between PA and PF, as was the case for urban boys.

The most important limitation of this study is its cross-sectional design. Therefore, causality cannot be specified. For example, while PA is generally considered the cause of PF status, it is still possible that the causality is the opposite. Therefore, future prospective studies are needed to explore this problem more specifically. Additionally, this study was performed in a specific geographical region with a mild climate, where children, especially those living in rural communities, can spend substantial amounts of time outdoors. Therefore, the results can be generalized only to similar populations.

Despite these limitations, this study has several strengths. First, this is one of the first studies in which correlations between PA and PF were specifically obtained for urban and rural children. This allowed us to contextualize the influence of the living environment on established associations between PA and PF. Additionally, PA activity was directly measured; therefore, identification of associations that exist between different intensities of PA and PF was possible. Finally, all children were measured over a short time span, and consequently, the PA results were not biased (i.e., because of the differences in weather conditions and time of the year).

CONCLUSION

Our findings underscore the importance of considering sociodemographic factors when examining the relationship between PA and PF. The observed differences in the associations between PA and PF between urban and rural boys may be influenced by socioeconomic disparities, cultural norms, and parental attitudes toward PA. For example, limited access to sports facilities and programs in rural areas, coupled with potential socioeconomic barriers, could restrict opportunities for children to engage in targeted PA and develop specific facets of PF. Addressing these sociodemographic factors is crucial for promoting health equity and ensuring that all children, regardless of their living environment, have the opportunity to achieve optimal PF.

This study emphasizes the need for tailored interventions that consider the unique challenges and opportunities presented by different living environments to promote PA and enhance PF in children. Future research should explore the long-term impact of these interventions and investigate the complex interplay of physiological, sociocultural, and environmental factors that contribute to the development of PF in children. By understanding these intricate relationships, we can develop more effective strategies to promote healthy lifestyles and improve the overall well-being of children, regardless of their background or where they live.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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