Faculteit Revalidatiewetenschappen

master in de revalidatiewetenschappen en de kinesitherapie

Masterthesis

Physical activity patterns and muscle quality in healthy school-aged children

Caroline Knapen
Valérie Minten

Scriptie ingediend tot het behalen van de graad van master in de revalidatiewetenschappen en de kinesitherapie, afstudeerrichting revalidatiewetenschappen en kinesitherapie bij musculoskeletale aandoeningen

PROMOTOR :
Prof. dr. Kenneth VERBOVEN

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Research Context

This research is part of the REVAL research center's study domain 'Health promotion and movement'.

With this master's thesis, we aimed to demonstrate that engaging in physical activity (PA) yields effective benefits for the human body and musculoskeletal system. We wanted to emphasize the importance of encouraging children to be physically active from a young age. The goal of this study was to show an association between muscle quality, sedentary behavior and PA patterns.

This thesis is part of the ongoing HAPHC (Healthy Active Performance with Happy Children) study. This project is guided by prof. dr. Hansen Dominique and in collaboration with the UCLL (University Colleges Leuven-Limburg) physical education course. It represents a collaboration among various European countries, including Norway, Austria, Slovenia, and Belgium. The purpose of this European research is to investigate the longitudinal impact of increased PA during school hours on the health of children aged seven to nine years. The intervention for the children included the addition of moderate-to-vigorous physical activity (MVPA) per day (outside of regular physical education classes), either during and/or between classes, using activity boxes. PA was recorded using accelerometers, and physical function was assessed through handgrip strength and aerobic capacity. In addition, anthropometric characteristics of the children were collected. Finally, data on blood pressure, quality of life, nutrition, and cognition of the children were also gathered. This master's thesis focused on the interaction between PA and muscle quality in Belgian children, based on the baseline measurements performed at the start of the intervention period. Interventional data were not included in the current thesis.

In the context of our master's thesis, we actively participated in the collection and processing of the data. We accompanied the research team to schools where we performed measurements and PA assessments. The ultrasound measurements performed by our supervisor, prof. dr. Verboven Kenneth, were analyzed by us. To write this thesis, we performed statistical analyses on the collected data and formulated the research question in collaboration with our supervisor.

Acknowledge

Our gratitude is extended to prof. dr. Verboven Kenneth, whose keen insights and depth of knowledge have enriched the quality of our thesis during its completion. His expertise and mentorship have played a pivotal role in shaping the outcome of our research. We feel privileged to have had the opportunity to work under his supervision and to be part of his research team.

Abstract

Background: The rise of technology has various benefits for the community, but it certainly has disadvantages as well. Children spend more time on their mobile phones, laptops, and TV, leading to a significant increase in sedentary behavior. This lifestyle has potentially adverse effects on their health, fitness, and well-being.

Objectives: This cross-sectional and observational study aims to explore potential associations between muscle quality and the level of physical activity in Belgian children aged seven to nine years.

Methods: Muscle quality of the rectus femoris was assessed through 2D ultrasound measurements, considering echo intensity and muscle thickness. ActiGraph devices were worn by the children to measure physical activity, including daily step count, sedentary time, and active time per day.

Results: The study includes 48 children aged between seven and nine years, with a mean of eight (± 0.9) years. Both boys (n=25) and girls (n=23) were enrolled in the study. The mean value for echo intensity was 47 (± 13) and the average muscle thickness was 1.68 (± 0.26) centimeter. Simple and multiple linear regressions models showed no significant associations between muscle quality and physical activity variables.

Conclusion: Based on these data, no clinical recommendations can be made given the absence of significant correlations between muscle quality and physical activity. Further research is recommended to provide clear answers to the research question.

Keywords: physical activity, children, muscle quality, ultrasound

Introduction

Previous research proves that increased screen time is correlated with various detrimental health outcomes among children and young people. Moreover, evidence is particularly found in relation to obesity, poor dietary habits, symptoms of depression, and diminished quality of life (Stiglic & Viner, 2019). “Replacement of prolonged sedentary time with moderate to vigorous physical activity may be the preferred scenario for behaviour change, given beneficial associations with a wide range of cardiometabolic risk factors (including adiposity, HDL-cholesterol, blood pressure and clustered cardiometabolic risk).” (Wijndaele et al., 2019).

The WHO (World Health Organization) has established general guidelines outlining the physical requirements for children and adolescents aged between five and 17 years. On a daily basis, the guidelines advocate for a minimum of one hour of MVPA for this age group (World Health Organization, 2022). Moderate-intensity activities are characterized by exertion levels that result in a three to six times higher energy burning per minute compared to resting or sedentary behavior, corresponding to exercises rated at three to six metabolic equivalents (METs). On the other hand, vigorous-intensity activities exceed six METs in energy expenditure (Harvard T.H. Chan, n.d.). Additionally, a regimen involving specific training to strengthen muscles and bones is recommended at least three times a week (World Health Organization, 2022).

Of interest, there is an emphasis on minimizing sedentary behavior (World Health Organization, 2022). “Sedentary behavior is any waking behavior characterized by an energy expenditure ≤ 1.5 metabolic equivalents (METs), while in a sitting, reclining or lying posture” (Tremblay et al., 2017). The WHO states that PA in children and adolescents is beneficial for physical fitness, which includes both cardiorespiratory and muscular fitness. In addition, there are improvements in cardiometabolic health, bone health, cognitive function, mental health, and the amount of adipose tissue (World Health Organization, 2022).

A systematic review by Poitras et al. (2016) summarized that PA was positively correlated to several aspects of health in children, including physical, cognitive, and psychological/social health. Their findings provided strong and consistent evidence supporting the beneficial association between overall PA and health parameters, such as adiposity, cardiometabolic biomarkers, physical fitness, and bone health. Moreover, their research indicated potential positive associations between overall

PA and health components, such as quality of life/well-being, psychological distress, and motor skill development (Poitras et al., 2016).

Diminished muscle quality is associated with an increased risk of diseases such as heart attacks and type 2 diabetes mellitus; furthermore, it also results in reduced muscle functionality (García-Alonso et al., 2022). Echo intensity (EI) reflects the amount of adipose tissue and/or connective tissue in a muscle. Increased EI indicates a higher concentration of fat within the muscle, correlating with diminished muscle quality (Young et al., 2016). Consistent with Young's findings, Stock and Thompson (2021) concluded that EI is a reliable indicator for the assessment of muscle quality in the general population (Stock & Thompson, 2021). In addition, muscle thickness (MT) is an indicator of muscle quality and related to muscle strength, physical function, and muscle mass (Isaka et al., 2022).

García-Alonso et al. (2022) investigated the correlation between EI and physical fitness components in children aged five to nine years. The components that were considered are cardiorespiratory fitness, handgrip strength, a standing long jump, speed agility, and general fitness. It is suggested that increasing PA levels is an important factor to prevent functional decline and metabolic disorders because these PA components were individually negatively associated with EI (García-Alonso et al., 2022). Based on this study, the significance of encouraging PA among children can be highlighted to promote optimal muscle quality and prevent muscle deterioration and functional decline in the future (García-Alonso et al., 2022).

Because of the lack of information on the relationship between muscle quality and objectively measured PA patterns in school-aged healthy children, this study investigated this concept. The aim is to assess the total level of PA (MVPA and steps per day) and the amount of sedentary time in children aged seven to nine years and to examine the potential association(s) with muscle quality variables (EI and MT).

This study hypothesizes that there will be a positive correlation between muscle quality (EI and MT) and the levels of PA, as well as a negative correlation between muscle quality and sedentary time.

Methods

Study design and participants

This research is part of the HAPHC study. The goal of the HAPHC study is to analyze the efficacy of an active teaching style and its impact on various outcome measures (e.g., cognition, blood pressure, physical fitness, etc.). This prospective study is a collaboration between several European countries and has a longitudinal and experimental design. The current cross-sectional data presented in this master's thesis represent a specific component of the HAPHC study.

Local schools were approached and invited to participate in the Belgian part of the HAPHC study. The schools that were willing to cooperate were geographically distributed throughout Limburg (located in Paal, Pelt, Hoepertingen, Bree and Genk). The recruitment specifically targeted children from the first, second, and third grade. In total, approximately 288 Belgian children were enrolled in the study. For this master's thesis, data of 48 of these children were used.

Selection criteria

Several inclusion criteria were developed for this paper. The study course and content were communicated to the teachers, students, and their parents. Only children (aged seven to nine years), who provided a signed informed consent by their legal representatives, could participate in the study. Both genders were allowed to participate. For some children, information regarding their gender was unavailable. These children were excluded.

Ethical Committee

This study (Belgian registration number: B1152021000024) was performed in accordance with the standards set by the latest revision (2013) of the Declaration of Helsinki and was approved by the Medical Ethical Review Committee of Hasselt University on the 17th of December 2021. Data protection and participant anonymity were ensured. Participation was strictly voluntary and required the signed informed consent from both the child and parent or a legal representative. Furthermore, the child retained the right to withdraw from the study at any point without incurring any consequences.

Procedure and measurements

Sociodemographic data (e.g., age and gender) of the children were obtained from class lists and anthropometric data (e.g., length and weight) were determined during the baseline testing.

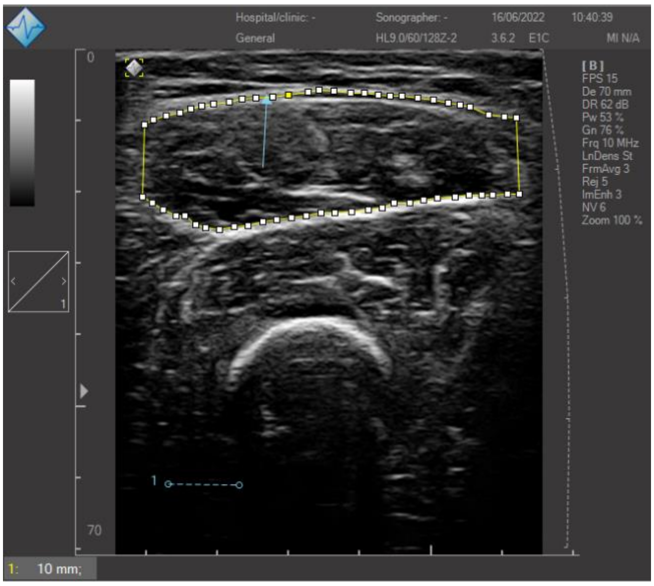
For the assessment of muscle quality, both EI and MT were examined. These parameters could be calculated by conducting ultrasound scans. The Echo Wave 2 software (Telemed, Lithuania) was used to generate the echograms. Two ultrasound scans were conducted for each child and analyzed individually using the ImageJ software program (version 1, developed by Wayne Rasband). These analyses were performed by two or three different examiners to enhance the inter-rater reliability. Calibration of the scale was required for each echogram to guarantee measurement accuracy. This was performed using the indicator line in the bottom left corner of the scan.

The ultrasound assessment was conducted as described in the paper of Müller et al. (2015). The measuring point on the rectus femoris was determined with the knee at an angle of 90°. Subsequently, a mark was placed at 14% of the body height, measured from the base of the patella (Müller et al., 2015). A gel was administered and the center of the probe was aligned perpendicular to the marked spot. The arm of the researcher rested on the child's leg to minimize pressure on the probe.

Using the polygon selection tool on the ImageJ software program, muscle circumference was defined to measure the EI. The researchers outlined the muscle by placing points on the inside of the fascia. To ensure accurate measurements, points were positioned no more than one centimeter from the edge in cases where the muscle extended beyond the scan. This precaution was taken because the scan edges could be distorted by the shape of the ultrasound probe, potentially affecting the measurements. This procedure is clarified in Figure 1. Subsequently, ImageJ automated the calculation of EI. Each researcher determined the EI using two echograms from the same child, and the mean of these measurements was calculated. Ultimately, the mean values from two or three investigators were combined into a single overall mean.

Figure 1

Analysis of Echo Intensity



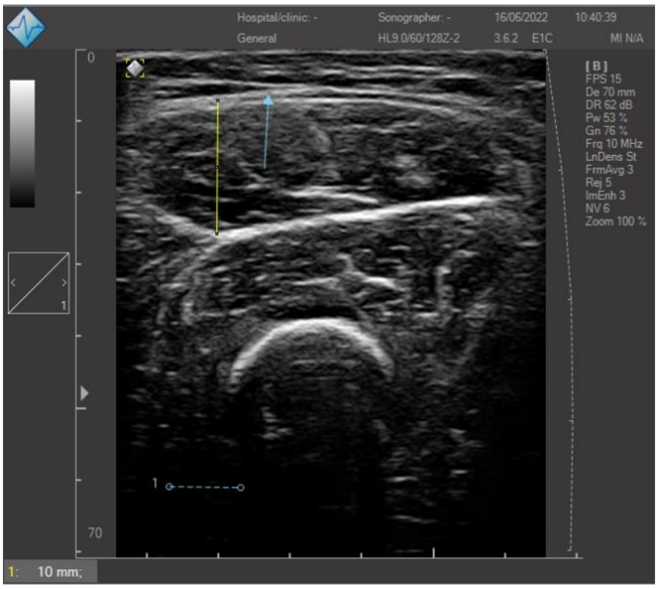
Note. Power = 53%; Gain = 76%; Frequency = 10 MHz; Yellow line = circumference of the muscle; Blue line = indication of the fascia.

EI serves as a reliable indicator to determine muscle quality and is expressed on a scale from zero to 255 (Scholten et al., 2003). This numerical value is defined by the color of the tissue, with lower values indicating darker tissue. As stated by Young et al. (2016), a higher number indicates a greater amount of fat tissue, resulting in lower muscle quality. Accordingly, muscles with a lower score are considered to be of higher quality (Young et al., 2016).

MT was calculated in addition to EI. Several random diameters were drawn from fascia to fascia on the thickest part of the muscle using the freehand line tool. To ensure accuracy, it was recommended to draw the diameters vertically at an angle of 89-91° to the X-axis. This procedure is illustrated in Figure 2. Thereafter, ImageJ automated the distance calculation. The longest distance of all the measurements was used for analysis. This procedure was repeated for the two different echograms. Mean values were calculated for individual examiners based on these two measurements with an overall mean derived from values obtained by two or three examiners.

Figure 2

Analysis of Muscle Thickness



Note. Power = 53%; Gain = 76%; Frequency = 10 MHz; Yellow line = muscle thickness (diameter); Blue line = indication of the fascia.

To assess inter-rater reliability for the EI and MT data, a score was calculated ranging from zero to one. "Values less than 0.5 are indicative of poor reliability, values between 0.5 and 0.75 indicate moderate reliability, values between 0.75 and 0.9 indicate good reliability, and values greater than 0.90 indicate excellent reliability." (Koo & Li, 2015).

Physical activity assessment

PA was evaluated using accelerometers (ActiGraph WGT3X+, ActiGraph LLC, United States of America). Children wore the device consistently for a total duration of eight days, securing it around the waist. The monitor had to be removed during water-related activities, such as showering or swimming. There would be no difference in the results whether the device was worn at night, as the data collected during these hours were excluded. Parents had to keep a diary noting the bedtime and waking time of the child.

Based on the diaries, the sleeping hours of the child were erased manually from the hourly database. Unfortunately, data of the diaries from 15 children were not accessible during the data processing phase. An alternative method was employed for the data processing to exclude sleeping hours. The waking times of these children were assessed by examining their active calorie expenditure. Hours with an energy expenditure below 40 calories per hour were excluded, presuming the child was asleep, as energy consumption was often below this threshold before waking but notably increased afterward. This cut-off was determined based on observations from children with available diaries.

The ActiGraphs were set to measure PA from midnight on the first day until midnight one week later. Each device was programmed for a specific child based on their gender and weight, enabling the software to calculate individual data. The analysis of ActiGraph data focused on three primary outcome measures: daily step count, daily duration of active minutes (including moderate, vigorous, and very vigorous activities), and daily sedentary minutes.

ActiLife (version 5, ActiGraph, United States of America) was used to install the ActiGraphs and extract information. The exported data was accessible in graphs and Excel files. The graphics visually represented the child's PA pattern for the week, while the Excel files displayed data for a single child over eight days (expressed in hours). Important parameters were manually selected for a concise summary in an Excel file, which also incorporated personal characteristics such as gender, age, height, etc.

Following the exclusion of sleeping hours, four random days were selected according to the criteria of having a minimum of eight consecutive hours per day and including at least one weekend day. The active minutes, sedentary minutes, and steps per day were summed up for the four individual days. Afterward, the average per parameter was calculated.

Statistical analysis

Statistical analyses were conducted using the JMP PRO 17 software (2022, JMP, United States of America). This study examined the associations between EI and steps per day, EI and sedentary minutes, and EI and active minutes. These individual associations were assessed through simple linear regression models. In addition, a multiple linear regression model was used to explore the association between all three factors and EI. The second part of the statistical analysis involved examining the associations with MT instead of EI. The above-mentioned procedure was repeated in the same manner.

Individual associations

The statistical decision tree "Continuous Data with the Influence of Categorical and/or Continuous Variables" (Meesen & Verstraelen, 2022) used for the analysis of the data, can be found in Figure 3 in the appendix. Based on this tree, a simple linear regression model was obtained to examine the individual associations. The initial step was to assess whether the data were independent or repeated. All data from the sample were independent. Secondly, the number of explanatory variables was taken into account. Considering one single continuous variable, the assumptions of normality, homoscedasticity, and linearity had to be checked.

The first assumption involved verifying normality by conducting the Shapiro-Wilk test. For the different associations with EI, the data were found to be normally distributed. However, the associations between MT and each parameter did not follow a normal distribution. To address this issue, transformations were performed on this data. The transformation used was the "square root" of all variables because the data exhibited a slight right skew (Vadali, 2017). This indicates that the mean is more positively related to the median, resulting in an overestimation of most of the variables (Clement, 2019). In most cases, a transformation ensured normalization of the data. With this transformed data, statistical analyses were conducted once again.

Thereafter, homoscedasticity and linearity were examined. For both assumptions, the "Residual by Predicted Plot" was assessed. Regarding homoscedasticity, the distribution of the data relative to the null line was evaluated. For linearity, the pattern of the data was observed, this should be straight-lined. Both assumptions were consistently fulfilled.

Combined associations

Based on the same decision tree (Meesen & Verstraelen, 2022) as used for the individual associations, a multiple linear regression model was selected. The measurements were independent in each case and multiple explanatory variables were present, all continuous in nature. Therefore, the assumptions of normality, homoscedasticity, and linearity needed to be verified. These were checked in a similar way to the individual associations and were all fulfilled. Consequently, the multiple linear regression model was chosen.

Parameters

Table 2 and Table 3 provide an overview of the parameters investigated in each association. The determination coefficient (R^2) is a measure of how well the regression line represents the observed data. It indicates the percentage of variance explained by the regression line. The R^2 ranges from zero to one, with an R^2 below 0.70 suggesting poor model fit, values between 0.70 and 0.85 indicating moderate fit, and values above 0.85 demonstrating good fit (Fernando, 2024).

The correlation coefficient (CC) can be obtained by taking the square root of the R^2. It signifies both the strength and direction of the linear relationship between two variables. The value ranges between minus one (which represents a perfect negative linear relationship) and one (indicating a perfect positive linear relationship). A CC of zero indicates that no linear relationship exists (Nickolas, 2023).

Lastly, the Degrees of Freedom (DF) are presented in the table. This number refers to the highest number of logically independent values and is determined by subtracting one from the overall count of participants in the dataset (Ganti, 2024).

Results

The characteristics of the study population can be found in Table 1. For this thesis, 23 girls and 25 boys were included, with the average age of eight years. Overall, the children had a sedentary time of approximately nine hours per day. Additionally, the mean number of active minutes was around 200 per day. Subsequently, it was observed that an average of 10,340 steps were taken per day. Based on the measurements, it could be concluded that the mean EI was 47 and the average MT was 1.68 centimeter.

Table 1

Characteristics of the Study Population

Parameters	Mean (± SD) (Population: 48 children)	Min; Max
Age	8 (± 0.9)	6; 9
Sex	Boys: 25 Girls: 23	-
Length (cm)	128.7 (± 6.8)	117.9; 149.0
Weight (kg)	26.6 (± 5.0)	20.0; 43.0
BMI (kg/m^2)	16.00 (± 1.92)	12.80; 21.28
Sedentary (mean min/day)	538 (± 69)	400; 679
Total MVPA (mean min/day)	201 (± 44)	67; 335
Steps/day	10,341 (± 2,379)	2777; 16,335
EI	47 (± 13)	13; 70
MT (cm)	1.68 (± 0.26)	1.24; 2.4

Abbreviations
SD = standard deviation
BMI = body mass index
MVPA = moderate-to-vigorous physical activity
EI = echo intensity
MT = muscle thickness
cm = centimeter

The outcomes of the conducted analyses can be found in Table 2 and Table 3 in the appendix. The individual associations between EI and the three parameters of PA were examined. Based on the findings, it can be concluded that there was no significant relationship between EI and sedentary minutes (r=0.0473; p=0.7496), EI and steps/day (r=0.0807; p=0.5856) and EI and active minutes (r=0.0478; p=0.7468), indicating no association between the parameters. For the analysis with MT, the same conclusions can be drawn. There were no significant correlations between MT and sedentary minutes (r=0.0912; p=0.5374), MT and steps/day (r=0.2138; p=0.9557) and MT and active minutes (r=0.0102; p=0.9452), suggesting the absence of any association between these variables.

For the analysis of the multiple linear regression model with EI, it was shown that this association was not significant (r=0.0965; p=0.9369). Similarly, the multiple linear regression model with MT did not show any significance (r=0.0949; p=0.9397). This indicated that the combination of these various factors did not influence the magnitude of EI or MT.

To evaluate inter-rater reliability for the EI and MT data, it was observed that the differences between the measurements of the multiple researchers always ranged between 0.75 and 0.90, indicating good inter-rater reliability (Koo & Li, 2015).

Based on the results of the R^2, the regression line poorly represented the observed data as evidenced by the values clustering around zero (Fernando, 2024). In addition, the fluctuation of the correlation coefficient around zero suggested little to no correlation in this dataset, given that the CC values were below 0.30 (van Heijst, 2018).

Discussion

This study wanted to emphasize the importance of the association between PA and its effects on muscle quality. The aim was to persuade that children should be active starting from a young age.

The relationship between PA and muscle quality was examined in school-aged children. It was hypothesized that there would be a positive association between muscle quality and PA. In contrast, a negative correlation was expected between muscle quality and sedentary behavior. Based on the results of the statistical analysis, the hypothesis could not be confirmed as no significant associations were found that could support the hypothesis.

There was limited evidence available in existing studies regarding the association between PA and muscle quality in healthy children. Therefore, discussing (in)consistencies compared to similar studies was challenging. Poitras (2016) found that the sedentary time of children was associated with lower cardiometabolic health, cognition, and academic performance. Additionally, it demonstrated that increased PA was beneficial for health (Poitras et al., 2016). Secondly, García-Alonso et al. (2022) showed that PA may lead to reduced EI, indicating improved muscle quality.

The findings of the present study were inconsistent with the results of the previously discussed studies. Two primary factors could be responsible for this inconsistency. First, the current research exclusively investigated the association between muscle quality and PA, while prior studies incorporated additional parameters, such as general health or cognition. Consequently, no statements could be made regarding the associations of PA with other parameters. Second, this study did not succeed to identify significant associations between PA and muscle quality in contrast to the findings of García-Alonso et al. (2022). They concluded that there was a positive correlation between PA and muscle quality, which could not be confirmed in this research (García-Alonso et al., 2022).

Scholten et al. (2003) aimed to study normal values for MT and EI in healthy children aged one to 12 years. This study calculated MT using ultrasound and concluded that this value depends on the child’s weight. Other characteristics (such as age, gender, and height) did not significantly influence the MT. Normal values could be calculated based on weight using a specific formula. However, this calculation was less applicable for this paper because this thesis aimed to investigate the association between PA and muscle quality rather than assessing whether the children met the norms.

Furthermore, Scholten et al. (2003) also investigated normal values for EI in this population. For the quadriceps femoris, an average value of 35 (± 7) was found, where this thesis came to a mean of 47 (± 13). The mean values of EI between these studies closely align. However, the results should be interpreted with caution, as the children in the study of Scholten et al. (2003) were one to 12 years old and the article is dated from 2003. Therefore, no reliable conclusions can be drawn based on these normal values of the EI. Given this article and the absence of other normal values, it is challenging to define a good muscle quality.

Strengths

A first strength of this study was the implementation of a standardized procedure for conducting the ultrasound measurements, consistently carried out by the same person. Furthermore, the analysis of EI and MT was performed by two or three researchers for each child, enhancing the inter-rater reliability. Another advantage was the collaboration of two investigators in co-authoring this master's thesis, which ensured meticulous double-checking and the integration of diverse perspectives.

Secondly, the reliability of the data collection was enhanced based on the study of Hislop et al. (2014). Their investigation demonstrated that the ActiGraph GT3X was reliable when worn for a minimum of three days, seven hours per day, for assessing PA and sedentary behavior in healthy preschool children. Considering these findings, it was opted to take measurements of four days with a minimum of eight hours per day into account.

The final strength pertains to the validity of the ultrasound measurements. Högelin et al. (2022) found high inter-rater reliability in ultrasound scans for determining the quadriceps muscle thickness (Högelin et al., 2022). In addition, Hammond et al. 2014 concluded that a curved-array transducer with a portable ultrasound device resulted in valid, reproducible, and reliable measurements of the rectus femoris muscle (Hammond et al., 2014).

Limitations

First, inconsistencies were observed in the protocol for excluding sleeping hours. Although diaries were predominantly employed for this purpose, at one school, their unavailability necessitated the exclusion of sleeping hours based on calorie consumption. Consequently, this might lead to discrepancies in interpretation. In addition, certain activities were excluded as the devices were not waterproof. This could potentially result in the children being represented as less active than they actually were. Another fragility involved the limited representation of the general population of Belgian children, which could be exemplified by two causes: age and location. The focus was exclusively on children aged seven to nine years, all from four schools within the same province in Belgium.

When processing and interpreting the results, it was crucial to consider the potential presence of bias, which could influence the outcomes. One type of bias that might have manifested in this study was confirmation bias. This bias involved data processing conducted by the same researchers who authored the paper. A potential consequence of confirmation bias was the presentation of results in a more favorably light than they truly were. As discussed before, selection bias might have been present, given that all children were recruited from the same Belgian province. In addition, performance bias may occur, introducing the Hawthorne effect, wherein children might have modified their behavior during the week of measurements. This could create an illusion of heightened activity levels, potentially leading to inaccuracies in observed correlations. This type of bias is often observed in studies related to physical activity. The risk can be reduced by blinding the participants. However, in this study, blinding the participants is not feasible, thereby increasing the risk of performance bias (Scribbr, n.d.).

Clinical implications

The clinical implications of this study's findings are limited. Given the absence of relevant results, no recommendations can be formulated regarding the amount of physical activity required to ensure good muscle quality. When considering the implications for scientific research, it is reasonable that further investigation is needed in this specific domain and within this specific population. The authors of this master's thesis propose several recommendations for future research. First, it is advised to include a broader age range. The researchers of this thesis hypothesize that incorporating a wider range may lead to the observation of more pronounced differences between the subjects. Second, it is recommended to employ a methodology capable of capturing all forms of PA, including water-related activities. Third, consistency in data collection and processing is advised.

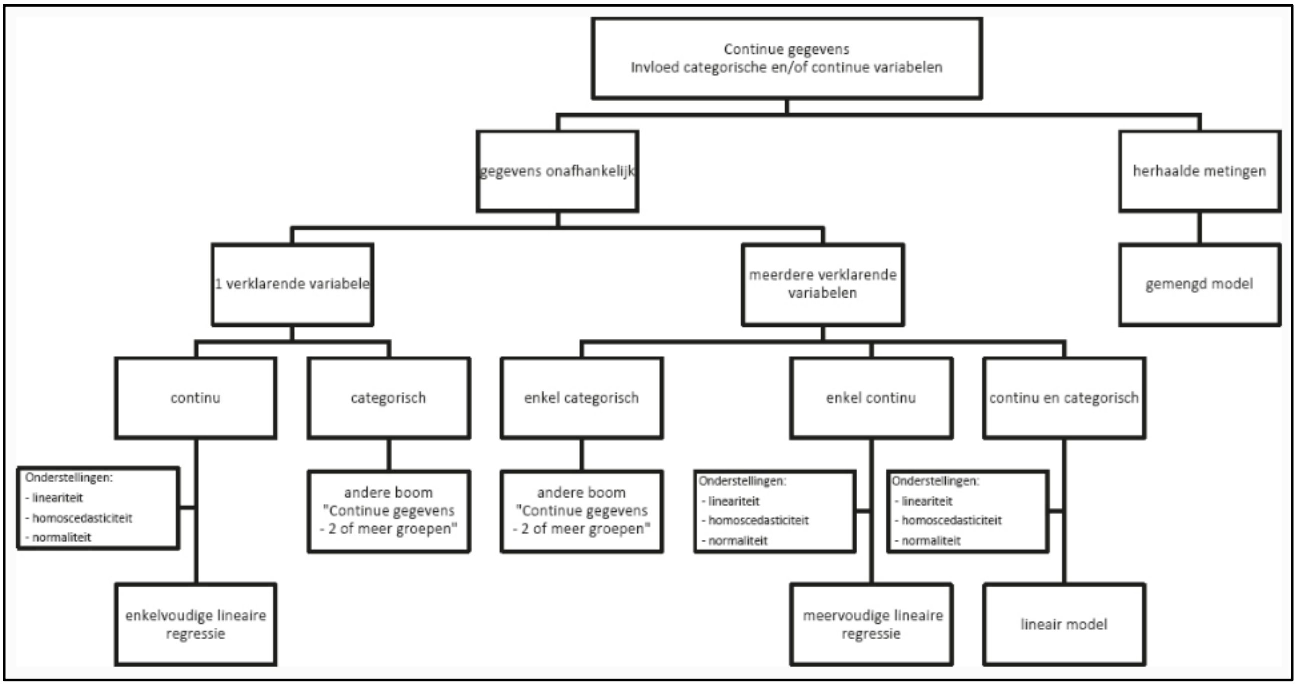
Conclusion

This study focused on exploring the association between PA and muscle quality in children aged seven to nine years, hypothesizing a positive correlation with active minutes or daily steps, and a negative correlation with sedentary behavior. No significant associations were found contrary to the hypothesis. The results of this research were inconsistent with existing literature, possibly due to the narrow focus on muscle quality and PA, without considering additional parameters such as general health, and the lack of significant associations. Consequently, while the general health benefits of PA are widely recognized, its specific impact on muscle quality in children remains inconclusive and warrants further investigation.

Appendix

Figure 3

Statistical Decision Tree: "Continuous Data with the Influence of Categorical and/or Continuous Variables"



Note. Meesen, R. & Verstraelen, S. (2022). *Cursus Wetenschappelijke Vorming: Deel 2* [Cursus]. Universiteit Hasselt Bachelor in Revalidatiewetenschappen en kinesitherapie.

Table 2

Correlations between Echo Intensity and Physical Activity

	Normality	R^2	CC	DF	P-value*
Sedentary Minutes x EI	0.5377	0.0022	0.0473	47	0.7496
Steps/Day x EI	0.6574	0.0065	0.0807	47	0.5856
Total MVPA x EI	0.5774	0.0023	0.0478	47	0.4768
(Sedentary Minutes x Steps/Day x Total MVPA) x EI	0.6644	0.0093	0.0965	47	0.9369

Abbreviations
EI = echo intensity
MVPA = moderate-to-vigorous physical activity
R^2 = determination coefficient
CC = correlation coefficient
DF = degrees of freedom

*p < .05

Table 3

Correlations between Muscle Thickness and Physical Activity

	Normality	R^2	CC	DF	P-value*
Sedentary Minutes x MT	0.3259	0.0083	0.0912	47	0.5374
Steps/Day x MT	0.3787	$6.786e^{-5}$	0.2138	47	0.9557
Total MVPA x MT	0.3856	0.0001	0.0102	47	0.9452
(Sedentary Minutes x Steps/Day x Total MVPA) x MT	0.3460	0.0090	0.0949	47	0.9397

Abbreviations
MT = muscle thickness
MVPA = moderate-to-vigorous physical activity
R^2 = determination coefficient
CC = correlation coefficient
DF = degrees of freedom

*$p < .05$

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