Sport Sciences for Health (2026) 22:245
https://doi.org/10.1007/s11332-026-01832-4

RESEARCH

Activities of daily living and upper extremity exercise capacity in individuals with high and normal body mass index

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Received: 3 February 2026 / Revised: 18 June 2026 / Accepted: 19 June 2026

Abstract

Background Although pathophysiological effects of high body mass have been widely studied, its impact on daily living activities and upper extremity performance remains unclear. The aim of this study was to compare activities of daily living (ADL), upper extremity exercise capacity, fatigue and pain perception in individuals with high and normal body mass index (BMI).

Methods This cross-sectional study included 54 adults aged 18–65 years who were classified into high BMI (BMI ≥ 25 kg/m^2, n = 27) and normal BMI (BMI 18.5–24.9 kg/m^2, n = 27) groups. Activities of daily living and upper extremity exercise capacity were assessed using the Glittre-ADL test and the 6-minute pegboard and ring test (6PBRT), respectively. Fatigue severity was measured with the Fatigue Severity Scale (FSS), and pain was assessed using the Visual Analogue Scale (VAS).

Results The high BMI group performed significantly worse than normal BMI group in both Glittre-ADL test ($p < 0.05$) and 6PBRT ($p < 0.001$). However, there were no significant differences in FSS and VAS scores between the two groups ($p > 0.05$).

Conclusion Individuals with high BMI demonstrated poorer performance in activities of daily living and upper extremity exercise capacity compared with those with normal BMI, despite reporting similar levels of fatigue and pain. These findings suggest that functional limitations may be present even in the absence of increased symptom perception. Therefore, objective assessment of functional performance should be considered when evaluating individuals with high BMI and planning rehabilitation interventions.

Keywords Overweight · Obesity · Functional performance · Upper limb endurance · Symptom perception

Introduction

In recent years, there has been increasing interest in the functional consequences of overweight and obesity. In addition to increasing the risk of metabolic and cardiovascular diseases, excess body weight may impair physical performance, reduce exercise capacity, and limit the ability to perform activities of daily living independently [1–4]. A recent systematic review and meta-analysis reported that a higher body mass index (BMI) is associated with an increased risk of impairment in activities of daily living (ADL), and that excess body weight can negatively impact functional independence [2]. Obesity has been shown to be associated with spending more time on personal care activities. This suggests that these individuals may require additional time to perform activities of daily living, such as bathing, dressing and moving around [5].

The negative effects of increased BMI on functional performance are thought to stem from both physiological and mechanistic factors [6, 7]. High BMI is often accompanied by excessive fat accumulation. Higher BMI has been associated with alterations in skeletal muscle structure and function, including reduced capillary density, impaired blood flow, and decreased oxygen utilization. These changes can lead to earlier fatigue and decreased exercise capacity. Additionally, decreased muscle capacity due to fatigue can affect the risk of injury and work performance. Research has indicated that obese individuals tend to require more time to execute upper limb movements [8]. On the other hand, obese

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Published online: 03 July 2026

individuals report more pain than individuals with normal weight. This can lead to functional impairments [9].

Excess body weight can also negatively affect upper extremity exercise capacity. Most daily living activities require upper extremity activity. Therefore, decreased upper extremity performance can contribute to difficulties in independently performing daily activities. Despite its clinical significance, upper extremity exercise capacity has received far less attention compared to mobility-related outcomes in individuals with a high BMI [10, 11]

Previous studies have objectively assessed activities of daily living in individuals with obesity using performance-based measures. For example, Monteiro et al. evaluated activities of daily living using the Glittre-ADL test in individuals with obesity and individuals who had undergone bariatric surgery [6, 12]. However, most studies investigating the relationship between BMI and ADL impairment have relied on self-reported disability questionnaires and ADL scales. Consequently, objective assessment of ADL performance using performance-based functional tests remains limited [2]. In addition, studies directly comparing objectively measured ADL performance, upper extremity exercise capacity, fatigue perception, and pain perception between individuals with high BMI and those with normal BMI are scarce. Therefore, the aim of this study was to compare activities of daily living, upper extremity exercise capacity, fatigue perception, and pain perception between individuals with high and normal BMI.

Methods

This cross-sectional study was conducted at the Department of Physical Therapy and Rehabilitation, Kırşehir Ahi Evran University, from December 2024 to June 2025. The Kırşehir Ahi Evran University Health Sciences Scientific Research Ethics Committee (2024-20/174) approved this study and written informed consent was obtained from each participant. Participants were recruited through advertisements posted within the university campus and through voluntary applications from university students, staff members, and community volunteers. Individuals who expressed interest in participating were screened for eligibility by a physiotherapist with more than 10 years of clinical and academic experience according to the predefined inclusion and exclusion criteria. All outcome assessments were performed with the participation of the research team physiotherapists. Eligible participants were then assigned to either the high BMI group (BMI ≥ 25 kg/m^2) or the normal BMI group (BMI 18.5–24.9 kg/m^2) based on their measured BMI values. The inclusion criteria for individuals with a high BMI were as follows: BMI ≥ 25 kg/m^2 and being between the ages of 18–65. The exclusion criteria for individuals with a high BMI were as listed below: Having a chronic or systemic disease that is known about, comorbidities that may affect physical function, a history of bariatric surgery and being pregnant. The inclusion criteria for individuals with a normal BMI were as follows: BMI 18.5–24.9 kg/m^2 and being between the ages of 18–65. The exclusion criteria for individuals with a normal BMI were as listed below: BMI ≥ 25 kg/m2 or ≤ 18.5 kg/m^2, having a chronic or systemic disease that is known about, comorbidities that may affect physical function. BMI was preferred because it is a simple, inexpensive, and widely used clinical screening tool for categorizing body weight status in studies [13].

All assessments were conducted over two separate study visits. During the first visit, demographic and anthropometric characteristics were recorded, and pain and fatigue perceptions were assessed using the Visual Analogue Scale (VAS) and Fatigue Severity Scale (FSS), respectively. Participants then performed the Glittre-ADL test. The 6PBRT was administered during a second visit on a different day to minimize the potential influence of fatigue from the previous performance test. Standardized instructions were provided before each assessment.

Activities of daily living

The Glittre-ADL test is a standardized field test designed to evaluate the performance of activities commonly encountered in daily life. The test has demonstrated good validity and reliability for the assessment of functional performance in individuals with obesity [6]. During the test, female participants carried a 2.5 kg backpack and male participants a 5.0 kg backpack. Each trial began with the participant rising from a seated position, then walking as quickly as possible down a 10 m corridor that included a two-step staircase midway, toward shelves positioned at shoulder and waist height. Upon reaching the shelves, the participant sequentially transferred three 1 kg objects, one at a time, from the shoulder-height shelf to the waist-height shelf and then to the floor; the objects were then returned individually to the waist-height shelf and back to the shoulder-height shelf. The participant then returned along the same path to the starting point and sat down. The circuit was completed five times, and the total time required to complete all repetitions was recorded in minutes. Lower completion times indicate better functional performance. Previous studies have reported reference values and prediction equations for the Glittre-ADL test in healthy populations [14, 15]. Heart rate was recorded, and dyspnea, general fatigue, arm fatigue, and leg fatigue were assessed using the Modified Borg Scale (MBS) before and immediately after the test. The difference between post-test and pre-test values (Δ) was calculated and recorded for each parameter.

Upper extremity exercise capacity

The 6-minute pegboard and ring test (6PBRT) was used to assess participants' upper extremity exercise capacity. The 6PBRT has been shown to be a valid and reliable measure of upper extremity exercise capacity in individuals with overweight and obesity [10]. In addition, reference values for the test have been established in healthy populations [16, 17]. It was carried out using a board with two upper and two lower nails placed at shoulder height and above shoulder height (20 cm) of the participants. During the test, participants simultaneously used both hands to transfer ten light wooden rings from the lower pegs to the upper pegs and then back again, continuing this cycle for six minutes. The goal was to transfer as many rings as possible within the six-minute period, and the total number of rings moved was recorded at the end of the test [18]. Before and after the test, heart rate were measured, and dyspnea severity, general fatigue, and arm fatigue were rated using MBS.

Fatigue

Participants' fatigue was assessed using the Turkish version of the FSS, which has been shown to be a valid and reliable instrument for assessing fatigue severity in Turkish populations. The scale consists of nine items evaluating fatigue experienced during the previous week. Total scores range from 9 to 63, with higher scores indicating greater fatigue severity. An average score of 4 or higher is considered indicative of severe fatigue [19].

Pain

Pain intensity was assessed using the VAS, a valid and reliable instrument for measuring subjective pain intensity [20]. The VAS consists of a 10-cm horizontal line ranging from 0 (“no pain”) to 10 (“worst imaginable pain”). Participants were instructed to indicate their perceived pain intensity by marking a point on the line. No minimum or maximum pain score was required for study participation.

Statistical analysis

Statistical analyses were conducted using SPSS version 29.0. The sample size was calculated using G*Power software (version 3.1). The calculation was based on preliminary data obtained from an initial subset of participants. The mean 6PBRT score was 401.50 ± 48.75 rings in the high BMI group and 448.80 ± 44.92 rings in the normal BMI group, corresponding to an effect size of $d = 1.009$. Assuming a two-tailed α level of 0.05 and 95% statistical power, a minimum sample size of 27 participants per group was required. Description statistics were presented as the mean ± standard deviation ($X \pm SD$). The normality of the data was assessed using the Shapiro – Wilk test. Student's t test and Mann–Whitney U test were used to compare normally and non-normally distributed variables, respectively. The probability of error was set at p-values < 0.05.

Results

A total of 68 individuals were assessed for eligibility. Eleven individuals with high BMI were excluded (six declined participation, four had a chronic disease, and one had physical limitations), and three individuals with normal BMI declined participation. Consequently, 54 participants were enrolled in the study and all completed the assessments, no dropout occurred after enrollment. Table 1 presents the demographic characteristics of the participants. No significant differences were found between the groups in terms of age, gender distribution and height ($p > 0.05$). Individuals with a high BMI had significantly greater weights and BMI values than those with a normal BMI ($p < 0.001$). Of the participants in the high BMI group, 73.1% were overweight and 26.9% were obese.

Table 2 summarizes the between-group comparisons of activities of daily living, upper extremity exercise capacity, perceived fatigue, and pain. The high BMI group demonstrated significantly poorer Glittre-ADL test performance, completing the test in a longer time than the normal BMI group ($p < 0.05$) (Figure 1). The difference in Glittre-ADL performance demonstrated a moderate effect size ($r = 0.31$). Results from the 6PBRT demonstrated reduced upper extremity exercise capacity in individuals with a high BMI compared with their normal BMI counterparts ($p < 0.001$) (Figure 2). The difference in 6PBRT performance demonstrated a large effect size (Cohen's $d = 0.96$, 95% CI 0.39–1.52). Furthermore, the post-6PBRT change in heart rate was significantly lower in the high BMI group ($p < 0.05$). Changes in dyspnea, general fatigue, arm fatigue, and leg fatigue after the Glittre-ADL test and 6PBRT did not differ significantly between the groups ($p > 0.05$). Similarly, VAS and FSS scores did not differ significantly between the high and normal BMI groups ($p > 0.05$).

Discussion

This study investigated the differences in activities of daily living, upper extremity exercise capacity and perceptions of fatigue and pain among individuals with a high BMI and a normal BMI. The findings showed that individuals with a high BMI performed significantly worse on both the Glittre-ADL test and the 6PBRT. This suggests that they have reduced endurance in their upper extremities and reduced ability to perform daily activities compared to participants with a normal BMI. However, no significant differences were observed between the groups with regard to perceived fatigue and pain levels.

The poorer performance on the Glittre-ADL test among individuals with a high BMI in our study is supported by existing literature which shows that excess body weight negatively impacts both the mechanical and metabolic demands of ADL, resulting in impairment. Monteiro et al. used the Glittre-ADL test to assess activities of daily living in individuals with obesity, individuals who had undergone bariatric surgery, and healthy controls. They reported that participants with obesity required significantly longer time to complete the test and exhibited greater energy expenditure

Table 1 Comparison of demographic characteristics in individuals with a high and normal body mass index

Characteristics	High body mass index (n = 27) Mean ± SD/ Median (min–max)	Normal body mass index (n = 27) Mean ± SD/ Median (min–max)	p-values
Age (years)	23 (18–46)	23 (21–36)	0.467
Gender (Female/Male) (n)	12/15	17/10	0.275
Height (cm)	171.33 ± 9.63	170.07 ± 10.01	0.639
Weight (kg)	81.70 ± 10.09	63.67 ± 9.32	**< 0.001**
Body mass index (kg/m^2)	26.77 (24.98–35.25)	22.53 (18.73–24.34)	**< 0.001**

n Number, *SD* Standard deviation, *min* Minimum, *max* Maximum, *cm* Centimeter, *kg* kilogram, *m* meters

Data are presented as mean ± SD for normally distributed variables and median (min–max) for non-normally distributed variables. Independent samples t-test or Mann–Whitney U test was used for between-group comparisons as appropriate. Gender distribution was compared using the chi-square test.

Bold p-values indicate statistically significant differences between the groups ($p<0.05$).

Table 2 Comparison of activities of daily living, upper extremity exercise capacity, perception of pain and fatigue in individuals with a high and normal body mass index

Characteristics	High body mass index (n = 27) Mean ± SD/ Median(min–max)	Normal body mass index (n = 27) Mean ± SD/ Median(min–max)	p-values
Glittre-ADL test (minute)	2.46 (2.03–4.48)	2.28 (1.55–3.27)	**0.023**
ΔHR (beat/minute)	69 (18–93)	65 (31–87)	0.856
ΔDyspnea (MBS) (0–10)	3 (0–8)	3 (0.5–9)	0.972
ΔGeneral fatigue (MBS) (0–10)	2 (−1–6)	1 (−1–9)	0.388
ΔArm fatigue (MBS) (0–10)	1 (−5–4)	1 (−1–3)	0.810
ΔLeg fatigue (MBS) (0–10)	2 (0–7)	2 (0–6)	0.222
6PBRT (rings)	408.81 ± 61.45	461.78 ± 48.06	**< 0.001**
ΔHR (beat/min)	12.11 ± 11.75	19.74 ± 12.92	**0.027**
ΔDyspnea (MBS) (0–10)	0 (−1–2)	0 (−1–2)	0.174
ΔGeneral fatigue (MBS) (0–10)	0 (−4–3)	0 (−2–4)	0.383
ΔArm fatigue (MBS) (0–10)	4.04 ± 2.39	3.28 ± 1.84	0.197
Visual Analogue scale (0–10)	2.10 ± 1.53	1.82 ± 1.24	0.461
Fatigue Severity scale (1–7)	3.63 ± 1.43	3.50 ± 1.40	0.726

n number, *SD* standard deviation, *min* minimum, *max* maximum, Δ difference between post-test and pre-test values, *HR* heart rate, *MBS* modified Borg scale, *6PBRT* 6-minute pegboard and ring test

Data are presented as mean ± SD for normally distributed variables and median (min–max) for non-normally distributed variables. Independent samples t-test or Mann–Whitney U test was used for between-group comparisons as appropriate.

Bold p-values indicate statistically significant differences between the groups ($p<0.05$).

Effect sizes for the primary outcomes were $r = 0.31$ for the Glittre-ADL test and Cohen's $d = 0.96$ (95% CI 0.39–1.52) for the 6PBRT.

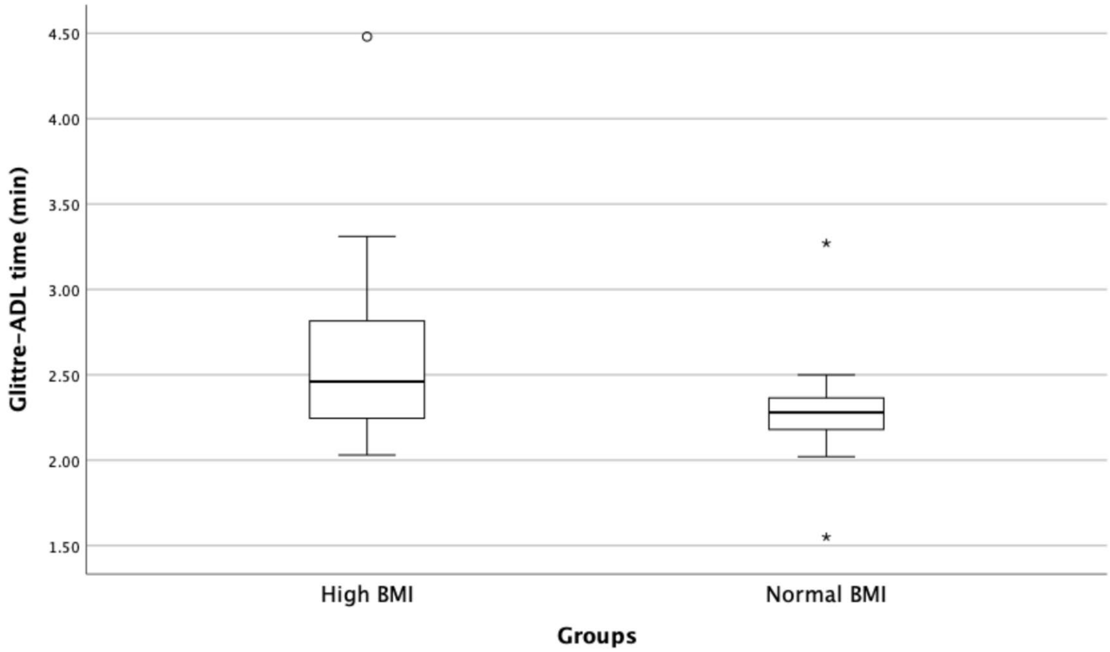

Fig. 1 Comparison of Glittre-ADL performance between individuals with high and normal BMI

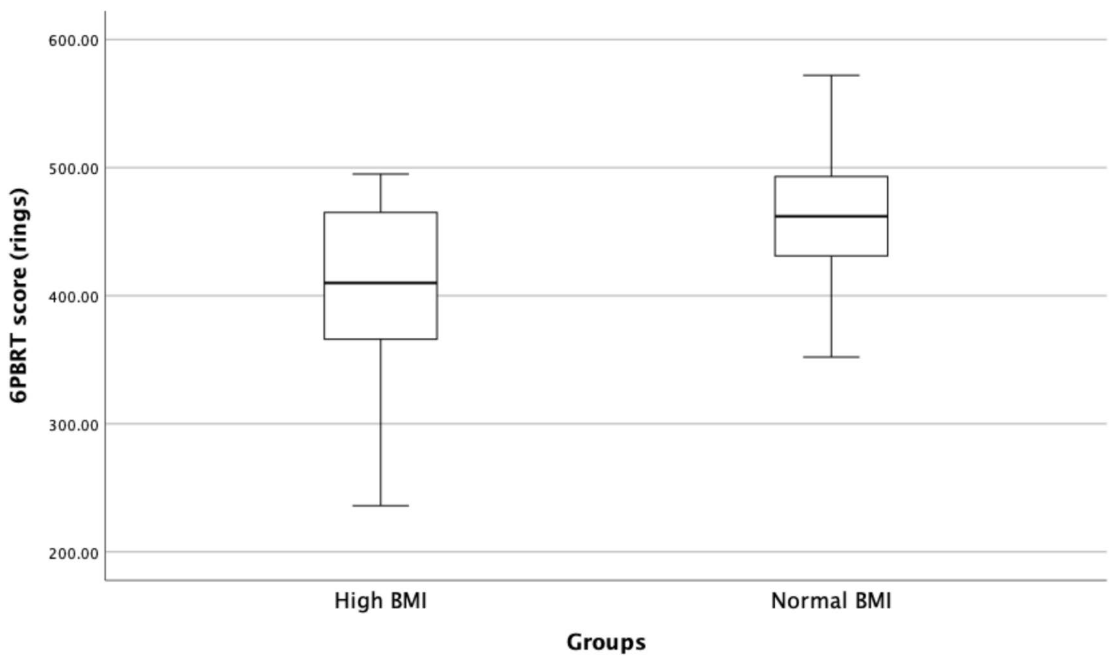

Fig. 2 Comparison of 6PBRT performance between individuals with high and normal BMI

during daily activities than healthy individuals. These findings suggest that excess body weight may adversely affect functional performance [6, 12]. However, unlike the study by Monteiro et al., the majority of participants in the present study were classified as overweight (73.1%) rather than obese. Therefore, direct comparisons between studies should be interpreted with caution. Nevertheless, our findings suggest that impairments in activities of daily living may also be present in individuals who are overweight, even in the absence of obesity. This finding is consistent with the results of other studies. To our knowledge, the majority of studies focus on elderly individuals, although there are no studies in the literature examining daily living activity limitations in young adults. A 22 year cohort study involving individuals aged 45–74 years showed that having a BMI over 25, particularly among women, increases the risk of reduced ability to perform ADL [21]. A study of older adults found that those who were overweight were more likely to experience difficulties with daily activities [22]. Supporting this conclusion, a study showed that obese female adolescents took significantly longer to complete the Glittre-ADL test than non-obese females [23].

In our study, the 6PBRT demonstrated that individuals with a high BMI exhibited significantly lower upper extremity exercise capacity than those with a normal BMI. This suggests reduced endurance and impaired performance in repetitive upper limb tasks. It has been reported that obese individuals have significant limitations in the range of motion of their upper extremities, including shoulder elevation and reach during occupational tasks. This further restricts repetitive arm use and endurance performance [24]. Additionally, a previous study suggested that obesity-related fatigue and neuromuscular dysfunction in the upper extremities may negatively affect movement. Pajoutan et al. compared young obese and non-obese individuals performing sustained isometric shoulder abduction tasks. They found that, with fatigue, obese individuals demonstrated a greater decrease in voluntary activation of motor units. Furthermore, obese individuals were found to experience an average torque loss of 14% per second [25]. By contrast, another study in which young adults performed constant-load tasks involving handgrip, shoulder flexion and trunk extension found that, while obese individuals had higher absolute strength, particularly for upper extremity tasks, their relative strength (i.e. strength per unit of body mass) was around 20% lower. However, there was no difference in endurance times. The authors of the aforementioned study found that obesity only had a mild effect on fatigue and performance during basic isometric activities. They recommended that future studies assess functional performance during more complicated activities [26]. In our study, we evaluated upper extremity performance and endurance using a test consisting of repetitive movements for six minutes rather than isometric activities. This approach may have better demonstrated functional loss in individuals with a high BMI.

Another finding is that the significantly smaller increase in heart rate after 6PBRT in the high BMI group may indicate the reduced cardiovascular response to exercise previously observed in overweight and obese individuals [27, 28]. In line with the findings of our study, Muthukrishnan et al. stated that overweight and obese young people showed changes in autonomic nervous system characteristics, causing lower parasympathetic activity and reduced heart rate variability [29].

Our study found no significant difference in VAS scores between the groups. The findings of research investigating the relationship between obesity and pain in the literature are controversial. A large-scale study reported that chronic pain prevalence increases linearly with BMI, with the greatest increase observed in obese individuals [30]. On the other hand, Emerson et al. reported that obesity has little effect on pain sensitivity and is not likely to increase the risk of developing chronic pain by exacerbating pain perception processes [31]. Actually, BMI may not be way to measure body fat percentage because it doesn't consider age or gender differences. Furthermore, given that the relationship between obesity, defined by BMI, and musculoskeletal pain affects both weight-bearing and non-weight-bearing joints, the underlying mechanism may be more complex than mechanical overload and BMI. It is possible that the fat mass index may provide a more accurate assessment of pain than BMI [32]. Many studies also demonstrate that obesity-related pain has multiple causes, involving both mechanical and inflammatory factors. Excess body weight is known to increase mechanical loading on joints and muscles, which may contribute to musculoskeletal pain [33]. In addition, adipose tissue contributes to systemic inflammation through the release of pro-inflammatory cytokines, including tumor necrosis factor-α (TNF-α) and interleukin-6 (IL-6). These mediators may sensitize nociceptors and thereby contribute to pain perception [34]. As the majority of participants in the high BMI group were classified as overweight rather than obese, the degree of adiposity, obesity-related inflammation, and mechanical stress in our sample may have been relatively limited. This may partly explain the absence of significant differences in subjective pain perception between groups despite reduced functional performance.

In addition, pain perception was evaluated using a subjective self-reported scale. Although the VAS is widely used and clinically practical, objective methods such as pressure algometry may provide a more sensitive assessment of pain threshold and sensitivity. Previous studies have demonstrated that pressure algometry is a reliable and valid method for assessing pain threshold [35, 36]. Therefore, future studies incorporating objective pain assessment methods maya help clarify the relationship between body composition and pain perception in individuals with high BMI.

Despite hypothesising that individuals with a high BMI would report greater fatigue due to the additional physical demands imposed by excess body weight, our results did not demonstrate a significant difference in fatigue perception between those in the high and normal BMI groups. This finding suggests that, in otherwise healthy adults, BMI alone may not be a reliable indicator of perceived fatigue. Whilst previous studies have reported an association between obesity and fatigue in different populations, it has also been emphasised that this association can be influenced by various factors [37, 38]. The report by Impellizzeri et al. included the following findings: an increase in the FSS score with an higher number of comorbidities in obese individuals;

a significant correlation between age and FSS; and a significant but small correlation between FSS and BMI [37]. Based on the results of the aforementioned study, it is possible that the FSS score remained low given that individuals with a high BMI in our study were relatively young and had a low BMI, as well as an absence of comorbidities. Another possible explanation is that impairments in functional performance may emerge before noticeable increases in subjective symptoms such as pain and fatigue. Although individuals with high BMI demonstrated reduced upper extremity exercise capacity and poorer ADL performance, these impairments may not yet have been severe enough to influence subjective symptom perception in this relatively young and otherwise healthy population.. Furthermore, it has been reported that fatigue is related to the level of pain, body fat percentage and quality of life experienced by women with knee osteoarthritis. The findings imply that body composition and symptoms like pain might be more significant than BMI in the development of fatigue [38].

This study has several limitations. First, its single-center design may restrict the generalizability of the findings to broader populations. Second, the use of BMI as the sole indicator of adiposity may be insufficient to accurately characterize body composition, as BMI does not distinguish between fat mass and lean body mass or provide information on fat distribution. More precise methods, such as bioelectrical impedance analysis or direct assessment of body fat percentage, could provide a more accurate characterization of adiposity. Third, most participants in the high BMI group were classified as overweight rather than obese. Therefore, the findings may be more representative of individuals with BMI $\geq$ 25 kg/m^2 and should not be generalized to individuals with obesity without caution. Finally, pain assessment was based on subjective self-report using the VAS. Objective methods such as pressure algometry may provide a more sensitive assessment of pain threshold and sensitivity in individuals with high BMI. Therefore, future studies incorporating direct body composition measurements and objective pain assessment methods are warranted.

Conclusion

This research study revealed that individuals with a high BMI have reduced functional capacity for daily living activities and upper extremity endurance. This is evident from their poorer performance on the Glittre-ADL and 6PBRT tests. These findings indicate that an increased BMI may adversely affect physical performance, even in individuals without chronic disease or severe obesity. In contrast, no significant differences were observed in perceived pain or fatigue between the high and normal BMI groups, underscoring the limitations of relying on BMI alone to reflect subjective symptom burden. Further research is warranted to explore these issues in greater depth, particularly through the use of more sensitive measures such as body fat indices and objective inflammatory markers.

Author contributions Conceptualisation: MF; Data curation: MF, GI, IC; Formal analysis: MF; Supervision: MF; Writing-original draft: MF, GI, IC; Writing-review and editing: MF.

Funding There is no financial support available for the study.

Data availability The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Conflict of interest The authors declare no competing interests.

Ethical approval Kırşehir Ahi Evran University Health Sciences Scientific Research Ethics Committee approved this study (2024–20/174). The study was conducted in accordance with the principles of the Declaration of Helsinki. All participants were informed about the study procedures, and written informed consent was obtained from all participants prior to their inclusion in the study.

Informed consent All participants were informed about the study procedures, and written informed consent was obtained from all participants prior to their inclusion in the study.

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