

Pengaruh Penggunaan Tas Ransel dan Tas Totebag Terhadap Pergerakan Center of Pressure Pada Anak Usia 8-12 Tahun

The Effect of Backpack and Totebag Use on the Movement of the Center of Pressure in Children Aged 8-12 Years

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Abstrak

Latar Belakang: Dua jenis tas yang umum digunakan adalah ransel yang mendistribusikan beban secara merata dan tas jinjing yang menempatkan beban di satu sisi tubuh. Penggunaan tas oleh anak-anak usia sekolah dapat memengaruhi keseimbangan postural mereka. Fisioterapi berperan dalam pendidikan ergonomi, latihan korektif, dan penguatan otot inti untuk mencegah gangguan muskuloskeletal akibat beban yang tidak seimbang. **Tujuan:** Studi ini bertujuan untuk menganalisis pengaruh penggunaan ransel dan tas jinjing terhadap pergerakan Pusat Tekanan (CoP) pada anak-anak berusia 8-12 tahun. **Metode:** Studi ini menggunakan 25 sampel yang dipilih dengan teknik sampling purposif, metode observasional, dan pendekatan eksperimental study. Pengukuran CoP dilakukan menggunakan Zebris FDM-s di laboratorium gymnasium Fakultas Ilmu Kesehatan, Universitas Muhammadiyah Surakarta. Analisis data meliputi analisis univariat, bivariat, uji normalitas Shapiro-Wilk, dan uji Mann Whitney dengan tingkat signifikansi $p < 0.05$. **Hasil:** Uji statistik Mann-Whitney menunjukkan tidak ada perbedaan signifikan antara kedua jenis tas terhadap pergerakan CoP ($p = 0.826$). Meskipun terjadi perubahan distribusi beban, tubuh anak masih mampu beradaptasi. **Kesimpulan:** Penggunaan ransel dan tas jinjing tidak secara langsung mempengaruhi keseimbangan postural anak dalam jangka pendek, namun penting untuk memperhatikan berat dan durasi penggunaan untuk mencegah gangguan muskuloskeletal jangka panjang.

Kata kunci: Center of Pressure, fisioterapi, keseimbangan postural, tas ransel, tas totebag

Abstract

Introduction: Two commonly used types of bags are backpacks that distribute weight evenly and totebags that put weight on one side of the body. The use of bags by school-aged children can affect their postural balance. Physiotherapy plays a role in ergonomics education, corrective exercises and core muscle strengthening to prevent musculoskeletal disorders due to unbalanced loads. **Purpose:** This study aims to analyze the effect of using backpacks and totebags on the movement of Center of Pressure (CoP) in children aged 8-12 years. **Method:** This study used 25 samples selected using purposive sampling techniques, observational methods, and an experimental study approach. CoP measurements were taken using the Zebris FDM-s in the gymnasium laboratory of the Faculty of Health Sciences, Universitas Muhammadiyah Surakarta. Data analysis included univariate, bivariate, Shapiro-Wilk normality test, and Mann Whitney test with a significance of $p < 0.05$. **Result:** The Mann-Whitney statistical test showed that there was no significant difference between the two types of bags on CoP movement ($p = 0.826$). Despite the change in load distribution, the child's body is still able to adapt. **Conclusion:** The use of backpacks and totebags does not directly affect a child's postural balance in the short term, but it is important to pay attention to the weight and duration of use to prevent long-term musculoskeletal disorders.

Keywords: backpack, Center of Pressure, physiotherapy, postural balance, totebag

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1. INTRODUCTION

In everyday life, bags are an important part of school-age children's activities, especially for carrying learning supplies such as books and stationery [1]. Children aged 8-12 years are experiencing rapid physical and motor growth. During this phase, posture is still developing and is vulnerable to external influences, including bag loads [2]. 59.7% of children aged less than 13 years most commonly use two types: backpacks and totebags in academic and non-academic activities. However, the difference in the way of carrying and distributing the load can affect the body balance and shift the Center of Pressure (CoP) [3]. Backpacks are popular because they make carrying items easier, distribute the load evenly, and reduce the risk of shoulder injuries. The load on a backpack rests more on the hip muscles, making it more balanced and stable [4], a totebag, on the other hand, has only one long strap that weighs down one side of the body, either carried or slung over the shoulder. These different ways of carrying a bag can potentially affect postural balance [5].

Several studies have shown that the use of non-ergonomic bags is associated with high rates of musculoskeletal disorders in school children. A total of 30.8% of children carried bags that exceeded 10% of their body weight, including loads on the musculoskeletal system. A total of 88.2% of students reported musculoskeletal problems, especially in the upper back, shoulders and neck [6]. Most muscle and joint pain in children is caused by the excessive weight and size of backpacks. About 8-75% of children and adolescents experience back pain, and 70% of students cite large backpacks as the main cause [7]. [1] found that 97.1% of children experienced postural discomfort after carrying a bag for too long, especially with excessive weight or non-ergonomic design. [8]. The use of totebags that tend to weigh down one side of the body can be more at risk of causing postural asymmetry [9]. Meanwhile, backpacks that are too heavy can increase spinal pressure, causing pain, posture changes, and gait disturbances. If it persists, this condition can lead to permanent changes [10].

Physiotherapy plays an important role in treating musculoskeletal disorders due to non-ergonomic bags [11]. A backpack that is too heavy or a totebag that weighs on one side of the body can change posture and balance, and risks causing back pain and spinal abnormalities [10]. Physiotherapy can provide corrective exercises to improve posture and strengthen core muscles so that children avoid the negative effects of the wrong bag carrying habits [8]. In addition, physiotherapists also provide education on the importance of equal distribution of weight to reduce pressure on one side of the body [11], such as the use of totebags with alternating sides at regular intervals to reduce the risk of imbalance due to weight resting on one side of the body only [12]. Physiotherapists can recommend balance and muscle strengthening exercises to improve body stability. These exercises help children adapt to changes in load without their balance being compromised. Research shows that multisensory training involving visual, vestibular and somatosensory stimuli is effective in improving balance in individuals with balance disorders [13]. With this approach, physiotherapy not only helps recovery, but also prevents postural problems early on.

The use of force plates to measure the position and displacement of the CoP is a commonly used technique in assessing posture stability statically and dynamically. [13]. CoP indicates how the body maintains balance by regulating weight distribution on the footrest [14]. When standing, optimal posture is maintained by muscle activity and the force of gravity. To maintain posture against the line of gravity (LoG), dynamic activation of postural muscles is required [15]. Changes in load distribution from using a backpack or totebag can shift the position of the CoP and affect body balance. CoP imbalance indicates the body's compensation for uneven load, which can trigger musculoskeletal disorders in the long term [16]. Small changes in the ability to balance posture can be detected by measuring the movement of the center of gravity or center of pressure. Shifts in the position of the CoP can indicate changes in the body's support mechanisms and increase the risk of injury or postural imbalance [17].

Previous research has addressed the impact of bags on postural health, particularly in relation to load distribution and pressure on the spine. However, studies specifically comparing backpacks and totebags on children's postural balance are limited. Some studies suggest that bags that are too heavy can increase spinal pressure and disrupt a child's walking pattern. However, there are still few studies that directly assess changes in CoP as an indicator of balance due to different bag designs. This study aims to examine the effect of using backpacks and totebags on the movement of the Center of Pressure (CoP) in children aged 8-12 years. Hopefully, the results of

this study can provide a deeper understanding of the biomechanical impact of bag selection on children's posture and body stability.

2. METHODS

2.1 Research Design

This study uses a quantitative design with observational methods and an experimental study approach. This approach allows data collection from several subjects at the same time. This method is expected to provide a clear picture of the effect of backpacks and totebags on CoP movement.

2.2 Setting and Sample/Participants

This study involved MI Muhammadiyah Gonilan students who met the inclusion and exclusion criteria. A total of 25 people were selected as samples using purposive sampling technique, then randomly divided into two groups: totebag (12 people) and backpack (13 people). This division aims to see the difference in the effect of the two types of bags on CoP movement. The research was conducted at MI Muhammadiyah Gonilan and the gymnasium laboratory of the Faculty of Health Sciences, Universitas Muhammadiyah Surakarta.

Inclusion criteria in this study included children aged 8-12 years, without a history of balance disorders, in good health and able to follow instructions. Children must also regularly use a backpack or totebag at least 5 days per week and be willing to participate in the study. Exclusion criteria included children with a history of foot, ankle, or knee injury in the past 6 months, as well as neurological disorders that affect balance. Children with limb length discrepancy >2 cm, postural disorders, use of mobility aids, not regularly carrying a bag, or unable to follow instructions were also excluded.

2.3 Measurement and Data Collection

Bag type refers to the model of bag used by the child, such as a backpack with two shoulder straps or a totebag carried on one side, which can affect the load distribution. Identification of bag type was done through direct observation and classified based on predetermined categories. The measurement used a nominal scale, because it only categorizes without comparing the level of use.

Bag weight is the mass of the bag used by the child, either a backpack or totebag, which can affect comfort and posture. Measurements were taken with a portable digital scale in kilograms (kg), when the bag was fully loaded with its contents. The scale was zeroed before the bag was stably placed. Data was analyzed using a ratio scale because it has an absolute zero and can be calculated mathematically.

Body Mass Index (BMI) is the ratio of body weight to height used to classify nutritional status according to WHO: underweight (<18.5), normal (18.5-22.9), overweight with risk (23-24.9), obesity I (25-29.9), and obesity II (>30) [18]. Measurements were taken with scales and microtoise, then calculated using the formula $BMI = BW \text{ (kg)} / TB^2 \text{ (m}^2\text{)}$. Data were analyzed with a ratio scale because it has an absolute zero and allows comparison.

The length of the child's limbs was measured to determine the difference between the right and left limbs which may affect posture and balance. Measurements were made using three methods: bone length (from the greater trochanter to the tuberosity of the tibia), true length (from the SIAS to the medial malleolus), and apperence length (from the umbilicus to the lateral malleolus), using a midline device. The child was asked to lie supine during the measurement. Results were measured in centimeters and analyzed with a ratio scale as it has an absolute zero and allows comparison.

Center of Pressure (CoP) is the center point of pressure of the moving body to help maintain balance. Changes in CoP reflect postural adaptation to external loads such as bags. CoP was measured using the Zebris FDM-S, a sensor-based device that records real-time plantar pressure in millimeters (mm) [19]. It is a force distribution system with high validity and reliability in posture and balance analysis [20]. The child is asked to stand barefoot on the platform in a relaxed position. Measurements were taken in three conditions: without a bag, wearing a backpack, and wearing a totebag. The Zebris sensor recorded the average value and variability of CoP to be

analyzed for changes in balance due to bag load [21]. Results were displayed as pressure maps and CoP movement graphs to evaluate the child's postural stability.

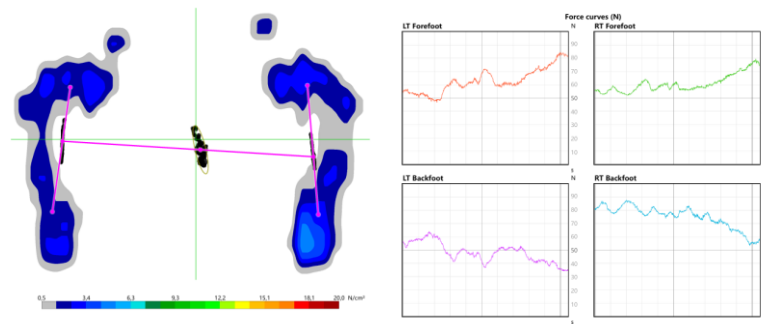


Figure 1. Zebris FDM-s

2.4 Data Analysis

Data processing was carried out using the IBM SPSS Statistics 20 application and through several stages of testing, namely: Univariate analysis to describe the characteristics of each variable, both independent and dependent variables. Data were presented in the form of frequency distribution tables and percentages for each variable. Furthermore, bivariate analysis was carried out on two X variables that were suspected of having a different influence on variable Y. Statistical tests in this study began with a data normality test which was analyzed using the Shapiro-Wilk table, considering that the number of samples used in this study was relatively small.

3. Result

3.1 Responden characteristics

After conducting research with 25 samples, some of the data reviewed in this article are as follows:

Table 1. Statistics on Demographic Characteristics of Respondents Without Comparison Group

Variables	Category	n	(%)
Age	8-9	8	32
	10-12	17	68
Gender	Female	14	56
	Male	11	44
Bag Type	Totebag	12	48
	Backpack	13	52

The descriptive characteristics of the respondents are summarized in table 1, with the aim to categorize without comparing levels or magnitudes. It was found that most respondents were aged 10-12 years (68%, n=17), with a small proportion aged 8-9 years (32%, n=8). In terms of gender, there were 56% (n=14) females and 44% (n=11) males. The types of bags used were almost equal, with 52% (n=13) using backpacks and 48% (n=12) using totebags.

Table 2. Statistics on demographic characteristics of respondents with comparison groups

Variables	Category	n	(%)
Bag weight	1-2.5	6	24
	2.6-3.5	13	52
	3.6-4.5	6	24
BMI	18.5-22.9	21	84
	23-24.9	4	16
	90-300	18	72
CoP without load	301-600	5	20
	601-1203	2	8
Dominat foot without load	Right	12	48
	Left	10	40
	Balance	3	12
Totebag load CoP	70-300	7	58.3
	301-600	1	8.3
Dominat Foot load totebag	601-1103	4	33.3
	Right	7	58.3
Backpack load CoP	Left	5	41.7
	70-300	11	84.6

	301-1103	2	15.4
Dominat Foot load backpack	Right	4	30.8
	Left	8	61.5
	Balance	1	7.7
Right & left bone length difference	<1	23	92
Right & left true length difference	1-2	2	8
	<1	25	100
Right & left apperence length difference	<1	24	96
	1-2	1	4

Key: Bag Weight (light: 1-2.5 kg, medium: 2.6-3.5 kg, heavy: 3.6-4.5 kg), BMI (normal or ideal: 18.5-22.9, overweight: 23-24.9), No Load CoP (good: 90-300 mm, medium: 301-600 mm, unfavorable: 601-1203 mm), Totebag Load CoP (good: 100-250 mm, medium: 251-400 mm, unfavorable: 401-600 mm), Backpack Load CoP (good: 70-300 mm, unfavorable: 301-1103 mm), Bone Lenght difference (light: <1 cm, medium: 1-2 cm, high: >2 cm), True Lenght difference (light: <1 cm, medium: 1-2 cm, high: >2 cm), Apperence Lenght difference (light: <1 cm, medium: 1-2 cm, high: >2 cm).

The characteristics of respondents based on the level or amount of data are summarized in Table 2. The majority of respondents (52%, n=13) carried bags weighing 2.6-3.5 kg, with the remainder using light (1-2.5 kg) or heavy (3.6-4.5 kg) bags. A total of 84% of respondents had a normal BMI (18.5-22.9), and 16% were classified as overweight (23-24.9). No-load CoP was in the good category (90-300 mm) in 72% of respondents, 20% were moderate (301-600 mm), and 8% were unfavorable (601-1203 mm). When carrying a totebag, 58.3% of respondents were in the good CoP category, 33.3% were unfavorable, and 8.3% were moderate. When using a backpack, 84.6% were in the good category and 15.4% were poor. The dominant leg without load was more right (48%) than left (40%) or balanced (12%). When carrying a totebag, the right leg dominance remained high (58.3%), but 41.7% shifted to the left. When using a backpack, the right leg decreased to 30.8%, with the left leg dominating (61.5%) and balanced (7.7%). Most respondents (92%) had a right-left bone length difference of <1 cm. For true length, all respondents were in the <1 cm range. In appearance length, 96% had a difference of <1 cm and 4% were in the range of 1-2 cm.

3.2 Data Normality Test

Table 3. Data Normality Test

Variable	Shapiro-Wilk	Sig. (p-value)	Description
BTT CoP	0.812	0.013	Abnormal
BTR CoP	0.624	0.000	Abnormal

Based on the results of the Shapiro-Wilk normality test (n<50) in table 3, it is known that the significance value (p-value) of the data is below 0.05. This indicates that the data distribution is not normally distributed, so the statistical analysis used in this study uses a non-parametric method, namely the Mann-Whitney test to test the difference between the backpack and totebag groups.

3.3 Effect Difference Test and Significance

Table 4. Bivariate Analysis

Center of Pressure (CoP) Movement	N	p-Sign
Totebag	12	0.827
Backpack	13	

*Significant at p < 0.005.
Key: N: total sampel

Based on table 3. It is known that the Mann Whitney statistical test obtained a p value of 0.827 (>0.05), it is concluded that H0 is accepted, so it can be seen that there is no difference in the effect between the use of backpacks and totebags on the movement of the Center of Pressure (CoP) in children aged 8-12 years.

4. DISCUSSION

This study aims to analyze the effect of using backpacks and totebags on the movement of the Center of Pressure (CoP) in children aged 8-12 years. Based on the results of the analysis, there was no significant difference between the two types of bags in affecting the movement of CoP (p = 0.827). This finding indicates that neither backpacks nor totebags have a statistically different impact on children's postural balance. However, there are several aspects that can be further discussed regarding how load distribution, postural adaptation, and other

biomechanical factors can affect children's body balance in the long run.

4.1 Comparison of Backpack and Totebag Use on Posture Balance

In this study, a backpack designed with two shoulder straps has a more even load distribution on both sides of the body [22], so in theory it is more ergonomic than a totebag that has only one strap and tends to burden one side of the body [23]. However, the results showed that these two types of bags did not cause a significant difference in CoP movement. This identifies that the bodies of children aged 8-12 years still have good biomechanical adaptability in overcoming changes in load distribution without causing significant balance disturbances.

4.2 Effect of Body Mass Index (BMI) on Posture Adaptation

The child's ability to adapt to the load being carried could be one of the factors explaining the absence of significant differences in CoP between the use of backpacks and totebags. In this study, most respondents (84%) had a normal BMI, which contributed to their ability to adjust their posture when carrying loads. When compared to individuals who have a higher BMI (overweight or obese), children with normal BMI have better compensation mechanisms so that changes in load distribution have less significant impact on their body balance [24].

In addition, the duration of bag use also needs to be considered. If the child only carries the bag for a short period of time such as when traveling from home to school, it is likely that the impact on CoP will not be too great. However, if the load carried is too heavy and used for a long time, then the biomechanical adaptation of the body is not effective enough in maintaining postural balance in the long term [25]. This has the potential to cause postural disorders, such as back pain, changes in walking patterns, as well as an increased risk of scoliosis in children who often use bags with uneven load distribution and for long durations of time [5].

4.3 CoP difference before and after carrying load

The results showed that before carrying weights, most children had a dominant foot on the right side (48%), while after using a totebag there was a change in the distribution of the dominant foot. The use of totebags tends to cause children to rest more on one side of the body, which in the long run can cause postural imbalance [23]. However, the shift in this study was too little to result in a discernible change in the mobility of CoP. The introduction of a backpack generated a minor change in leg dominance, but it had no discernible effect on overall CoP because the body still had to adjust to maintain balance even if the load was distributed more equally. The variation in leg dominance in this study demonstrates that, even with the altered load distribution, the body can still automatically balance posture.

Previous studies have shown that the use of bags that are not ergonomic can cause various musculoskeletal disorders and contribute to postural changes that can have long-term effects [17]. The use of heavy and poorly distributed bags can increase pressure on the spine and change the body's compensatory mechanisms in maintaining balance [8]. However, in this study most respondents used bags with a weight that was still within reasonable limits (2.6-3.5 kg). This is one of the reasons why the impact of bag use on CoP does not differ significantly. Postural balance and body load distribution systems are likely to be more severely impacted if the bag weighs more than the advised level of 15% of the child's body weight [23].

4.4 Effect of Bag Use on Center of Pressure (CoP) Movement

CoP is a biomechanical indicator that describes the distribution of body pressure when standing or moving [14]. Under normal conditions, the body has a complex balance regulation system that involves interactions between the musculoskeletal system, proprioceptive, as well as postural reflex mechanisms. The use of bags, especially with different loads, can change the weight distribution and require the body to adjust the balance to maintain a stable posture. The movement of the child's Center of Pressure (CoP) and postural balance may be impacted by variations in body weight distribution brought on by using overloaded bags. Uneven loads force the body to make postural compensations, such as leaning forward or to the side, to maintain balance [8].

In addition to the bag load, a number of additional variables that affect postural balance also affect CoP movement. One of the main factors is muscle strength and activation, especially core muscles and lower limb

muscles. These muscles are responsible for stabilizing the body while standing or moving. Weak muscle activation can lead to increased CoP shifts, which risks decreasing body balance [15]. In addition, body structure and posture also contribute to determining CoP stability. Differences in the shape of the spinal curvature, such as lordosis, kyphosis, or scoliosis, can affect body weight distribution and overall balance [9]. Foot dominance and standing habits can also lead to different CoP shift patterns, especially if the individual rests more often on one side of the body, which is further exacerbated by the habit of carrying asymmetrical loads such as totebags [26]. Muscle fatigue also has a significant impact on CoP. Strenuous physical activity or long duration of standing can cause fatigue in the neuromuscular system, so that the body's effectiveness in controlling balance is reduced [6]. Other external factors, such as the type of standing surface, also play a role in determining CoP stability. Softer or uneven surfaces can increase CoP movement as the body needs to make more adjustments to maintain balance [21].

According to studies, using bags that weigh more than 10% of one's body weight might cause postural instability and increase back muscular stress [5]. Several components of sensory, motor, and brain integration that maintain joint homeostasis through body movement form the sensorimotor system, which is important for postural stability [27]. Significant changes in CoP brought on by the usage of nonergonomic bags may also raise school-aged children's risk of developing musculoskeletal conditions including scoliosis and low back discomfort. Therefore, it is important to ensure the bag load remains within reasonable limits and ergonomic bag design to reduce the risk of postural imbalance [9].

This study's limitations cover a number of topics. First, the results may not be as broadly applicable to a larger population due to the very small sample size (25 respondents). Furthermore, the distribution of the contents in the bag, which could have an impact on the Center of Pressure's (CoP) movement, was not taken into account in greater detail in this study. Other external factors, such as children's physical activity, sitting habits, and duration of bag use were also not specifically analyzed, where these factors can affect postural balance [16].

To make the findings more representative, it is advised that a bigger and more varied sample be used in future studies. In addition, a more in-depth analysis of the duration of bag use, load distribution in the bag, as well as other biomechanical factors such as walking patterns and long-term changes in posture can be further investigated. Using a longitudinal method can also provide more insight into the cumulative impact of bag use on children's postural balance.

5. CONCLUSION

The findings of the study indicate that there is no discernible difference in the impact of backpacks and totebags on the movement of children between the ages of 8 and 12 ($p = 0.827$). This result indicates that neither backpacks nor totebags directly affect children's postural balance in the short term. Although in theory backpacks are more ergonomic because they distribute the load evenly across both shoulders, children's bodies in this age range are still able to adapt well to changes in load distribution. Most of the respondents had a normal Body Mass Index (BMI), which allowed them to adjust their posture effectively. In addition, the weight of the bags used was mostly within reasonable limits (2.5-3.5 kg), which did not cause significant changes in balance. To avoid long-term detrimental effects on children's posture and musculoskeletal health, it is crucial to consider the ergonomics of bag use. To lower the danger of postural imbalance, it is advised to use a backpack with adjustable shoulder straps, keep the weight of the bag no more than 10–15% of the child's body weight, and rotate the totebag from time to time.

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