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Relationship between Body Mass Index and Backpack Load with Shoulder Pain Complaints among First-Grade Junior High School Students

I Komang Adi Putra Yasa[1], I Gusti Ngurah Mayun[2], I Putu Astrawan[3]
[1,2,3]Physiotherapy Study Program, Faculty of Health Sciences, Universitas Bali Internasional, Denpasar, Indonesia

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***Corresponding Author*:**

I Komang Adi Putra Yasa
Physiotherapy Study Program,
Faculty of Health Sciences,
Universitas Bali Internasional,
Denpasar, Indonesia
Email:
ikomangadi1@gmail.com

ABSTRACT

Shoulder pain is one of the most common musculoskeletal complaints among school-aged adolescents and has the potential to interfere with learning activities and daily functioning. This complaint is thought to be influenced by various factors, including Body Mass Index (BMI) and the use of overweight backpacks, which may increase mechanical stress on the shoulder structures. This study aimed to determine the relationship between BMI and backpack load with shoulder pain complaints among first-grade students at SMP Negeri 5 Abiansemal, Badung, Bali. This study employed a quantitative analytical observational method with a cross-sectional design. The sample consisted of 78 students selected using a purposive sampling technique. BMI data were obtained through measurements of body weight and height, backpack load was measured using a digital scale, and shoulder pain complaints were assessed using the Visual Analogue Scale (VAS). Data were analyzed using the Chi-Square test with a significance level of $p < 0.05$. The results showed no significant relationship between BMI and shoulder pain complaints ($p = 0.532$), whereas a significant relationship was found between backpack load and shoulder pain complaints ($p < 0.001$), indicating that heavier backpack loads are associated with a higher risk of shoulder pain. Backpack load management is recommended as a strategy to prevent musculoskeletal complaints among students.

***Keywords*:**
Adolescents, Backpack Load, Body Mass Index, Shoulder Pain, Students.

1. INTRODUCTION

Nutritional status is commonly assessed using the Body Mass Index (BMI), a practical indicator calculated from body weight and height. BMI is determined by dividing body weight by the square of height and is generally categorized as underweight, normal weight, overweight, or obese. Among adolescents, being overweight or obese may have direct psychological consequences, including depression and negative body image, as well as indirect effects, such as low self-esteem, disordered eating tendencies, and reduced quality of life [1].

Regarding musculoskeletal complaints, particularly shoulder pain, studies examining the association between underweight or normal BMI and musculoskeletal symptoms are still limited. Individuals who are overweight or obese may experience difficulties in performing daily activities because of musculoskeletal pain. A higher BMI may also affect joint movement because excess adipose tissue around body segments can limit the joint range of motion [2]. Musculoskeletal problems in individuals with ideal body weight may be influenced by other factors, such as poor posture and prolonged static positions during daily activities. These conditions can increase the mechanical stress on the muscles, ligaments, and nerves [3].

Backpacks have become one of the most commonly used types of school bags among adolescents of both sexes, from elementary school through university and, in some cases, adulthood. The improper use of backpacks, particularly when they are carried for prolonged periods or loaded excessively, has been associated with various musculoskeletal complaints among adolescents [4], [8]. Approximately 40% of students have been reported to experience shoulder pain, while 88% experience neck and back pain when carrying their school bags [4]. To reduce the risk of musculoskeletal problems, the American Academy of Orthopaedic Surgeons recommends backpacks with two padded shoulder straps, back padding, and a waist belt, while also emphasizing that the backpack should be lightweight. Carrying an excessively

heavy backpack over time may contribute to changes in posture, such as drooping shoulders and increased thoracic kyphosis [4]. In addition, carrying a backpack for more than 20 min per day has been associated with the development of pain, while the American Chiropractic Association (ACA) recommends that backpack weight should not exceed 10% of an individual's body weight [5].

Shoulder pain during childhood and adolescence may be an early indicator of musculoskeletal problems that can persist into adulthood [6]. In adolescents, shoulder pain may occur due to repeated and prolonged pressure from backpack straps placed over the shoulder. The intensity of pain may increase as the backpack load becomes heavier, requiring the shoulder and surrounding muscles to work harder to maintain the load, resulting in increased muscle tension [7]. Although previous studies have widely investigated the relationship between overweight or obesity and musculoskeletal complaints, particularly low-back and neck pain, research examining the association between underweight and normal BMI categories, backpack load, and shoulder pain remains limited.

A preliminary observation conducted at SMP Negeri 5 Abiansemal showed that students carried backpacks with varying loads and had different body compositions (BCs). These observations raise the possibility that both BMI and backpack load may contribute to shoulder pain complaints among students. Therefore, this study aimed to determine the relationship between BMI and backpack load with shoulder pain complaints among first-grade students at SMP Negeri 5 Abiansemal, Badung, Bali.

2. METHODS

This study used a quantitative analytical observational method with a cross-sectional design in which BMI, backpack load, and shoulder pain complaints were measured simultaneously. The study was conducted among first-grade students at SMP Negeri 5 Abiansemal, Badung-Bali in February 2026. The target population comprised all first-grade students who used backpacks, and the accessible population consisted of students who met the inclusion and exclusion criteria.

The sample size was calculated using the Slovin formula based on a population of 351 students with a 10% margin of error, yielding a minimum sample of 77.82, which was rounded up to 78 students. Sampling was performed using a non-probability purposive sampling technique at a 95% confidence level. The inclusion criteria were as follows: students aged 12–13 years, shoulder pain VAS score ≥ 1, use of a backpack as the main school bag, BMI categorized as underweight, normal, overweight, or obese, willingness to participate and sign informed consent, and presence during data collection. The exclusion criteria were a history of shoulder injury within the previous three months and congenital musculoskeletal disorders (e.g., severe scoliosis and shoulder deformity).

The independent variables were BMI and backpack load, and the dependent variable was shoulder pain complaints. BMI was calculated as body weight (kg) divided by height squared (m^2) and categorized as underweight (<18.5), normal (18.5–22.9), overweight (23.0–24.9), or obesity I (25.0–29.0) [9]. Backpack load was expressed as the percentage of backpack weight relative to body weight and categorized as moderate (<10% of body weight) or excessive load (>10% of body weight) [10]. Shoulder pain was assessed using the Visual Analog Scale (VAS), a 10 cm scale ranging from 0 (no pain) to 10 (worst pain), and categorized as mild (1–3), moderate (4–6), or severe (7–10) pain [11], [12].

The instruments used included a digital scale (0.1 kg accuracy) for body weight and backpack weight, a microtoise for height, the VAS for pain intensity, observation sheets, and a self-report questionnaire on demographic characteristics and backpack-carrying habits. Data were collected directly by the researcher, assisted by the school liaison teacher and a physiotherapist, after obtaining institutional and school permits, ethical clearance, and informed consent from the participants. Data were processed using SPSS version 25.0. Univariate analysis described the characteristics of BMI, backpack load, and shoulder-pain intensity, while bivariate analysis using the chi-square test (significance level $\alpha = 0.05$) examined the relationship between BMI and shoulder pain and between backpack load and shoulder pain.

3. RESULTS AND DISCUSSION

3.1 Characteristics of Respondents

A total of 78 students met the inclusion and exclusion criteria of the study. All respondents were early adolescents aged 12–13 years, consisting of 25 students (32.1%) aged 12 and 53 students (67.9%) aged 13, which is consistent with the WHO classification of early adolescence; this stage is marked by a growth spurt with rapid but still biomechanically immature musculoskeletal development [13], [14]. Regarding sex, 47 (60.3%) respondents were male and 31 (39.7%) were female.

Table 1. Characteristics of Respondents

Characteristic	f	%
Age 12 years	25	32.1
Age 13 years	53	67.9
Male	47	60.3
Female	31	39.7
BMI: Underweight	26	33.3
BMI: Normal	24	30.8
BMI: Overweight	12	15.4

Characteristic	f	%
BMI: Obesity I	16	20.5
Backpack load: moderate	36	46.2
Backpack load: excessive	42	53.8
Duration <30 min/day	73	93.6
Duration >30 min/day	5	6.4
Pain with backpack: mild	37	47.4
Pain with backpack: moderate	41	52.6
Pain without backpack: mild	69	88.5
Pain without backpack: moderate	9	11.5

Most respondents were categorized as underweight (33.3%), followed by normal weight (30.8%), obesity I (20.5%), and overweight (15.4%); this distribution may reflect the dietary patterns, physical activity, and hormonal changes typical of this developmental stage [15]. Regarding backpack load, 53.8% of students carried excessive load (>10% of body weight). Shoulder pain intensity while wearing the backpack was dominated by moderate pain (52.6%), whereas without the backpack, most respondents reported only mild pain (88.5%), indicating that carrying a backpack substantially increases perceived shoulder discomfort, even though most students used the bag for less than 30 min per day.

3.2 Relationship between BMI and Shoulder Pain Complaints

Table 2. Cross-Tabulation of BMI and Shoulder Pain Complaints

	Shoulder Pain		Total
BMI Category	**Mild Pain**	**Moderate Pain**	
Underweight	23	3	26
Normal	20	4	24
Overweight	12	0	12
Obesity I	14	2	16
Total	**69**	**9**	**78**

The Chi-Square test yielded $p = 0.532$ ($p > 0.05$), indicating no statistically significant relationship between BMI and shoulder-pain complaints in this sample; therefore, hypothesis 1 was rejected. Theoretically, BMI could influence shoulder mechanical load in either direction: a low BMI is associated with reduced muscle mass and weaker supporting tissue around the shoulder, potentially lowering the tolerance to the mechanical stress of backpack use [2], [16], whereas a high BMI increases mechanical loading on the joints and can restrict the range of motion because of excess adipose tissue, increasing the risk of muscle strain or inflammation [16], [17]. Several population-level studies have reported that an elevated BMI is associated with musculoskeletal pain severity, including low-back pain and general musculoskeletal complaints [20], [21]. However, in the present study, the distribution of pain intensity was relatively even across BMI categories, suggesting that shoulder-pain complaints among these students were more strongly influenced by extrinsic factors such as posture, backpack-carrying habits, and backpack load than by BMI [18], [19]. This finding is consistent with the observation that data on the relationship between underweight/normal BMI and shoulder pain remain limited and inconsistent [2].

3.3 Relationship between Backpack Load and Shoulder Pain Complaints

Table 3. Cross-Tabulation of Backpack Load and Shoulder Pain Complaints

	Shoulder Pain		Total
Backpack Load	**Mild Pain**	**Moderate Pain**	
Moderate (<10% BW)	28	8	36
Excessive (>10% BW)	9	33	42
Total	**37**	**41**	**78**

Among students carrying excessive backpack loads, 78.6% experienced moderate pain, compared with only 22.2% of students carrying moderate loads. The Chi-square test yielded $p < 0.001$, indicating a statistically significant relationship between backpack load and shoulder pain complaints; therefore, ypothesis 2 was accepted. Excessive backpack loads increase the pressure on the trapezius and levator scapulae muscles and surrounding soft tissues, producing sustained muscle contraction, muscle fatigue, impaired local circulation, and increased mechanical stress, which manifest as shoulder pain [7], [22]. Heavy backpacks also promote compensatory postural changes, such as forward head posture and anterior trunk lean, to maintain the center of gravity, further increasing the activity in the shoulder and neck muscles

[18]. These findings are consistent with previous research reporting a significant relationship between backpack weight and shoulder pain complaints among school-aged children ($p = 0.000$) [7], [23], and support the recommendation that backpack weight should not exceed 10% of body weight [5], with both shoulder straps used evenly to distribute the load and reduce compensatory postural strain [24].

4. CONCLUSION

This study found no significant relationship between Body Mass Index and shoulder pain complaints ($p = 0.532$) among first-grade students at SMP Negeri 5 Abiansemal, Badung-Bali, whereas a significant relationship was found between backpack load and shoulder-pain complaints ($p < 0.001$). These findings indicate that backpack load is a more relevant biomechanical risk factor for shoulder pain in this population than BMI is. Schools, parents, and students are encouraged to monitor backpack weight, keep it below 10% of body weight, use both shoulder straps evenly, and maintain good posture to prevent musculoskeletal discomfort. Further research using longitudinal designs, larger and more diverse samples, and more objective pain-measurement instruments is recommended to clarify the causal relationship between these variables.

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