

School Bag Packs and Associated Problems among School Going Children

Schulrucksäcke und damit Verbundene gesundheitliche Probleme bei Schulkindern

Authors

Danish Hassan¹, Muhammad Kashif², Mohammad A. Mohseni Bandpei³, Summiya Qudrat Ali^{4, 5}, Abdul Raqib⁵, Nosheen Manzoor¹, Saima Zahid¹, Ahmed Rafiullah⁶

Affiliations

- 1 Riphah College of Rehabilitation Sciences, Riphah International University, Lahore, Pakistan
- 2 Rehabilitation and Allied Health Sciences, Riphah International University, Faisalabad, Pakistan
- 3 Pediatric Neurorehabilitation Research Center, University of Social Welfare and Rehabilitation Sciences, Tehran, Iran (the Islamic Republic of)
- 4 Riphah College of Rehabilitation Sciences, Riphah International University, Faisalabad, Pakistan
- 5 Physiotherapy Department, DHQ Hospital Dera Ismail Khan, Pakistan
- 6 Physiotherapy Department, DHQ Hospital, Layyah Punjab, Pakistan

Key words

adolescent, low back pain, bag pack

Schlüsselwörter

Jugendlichen, Rückenschmerzen, Rucksack

received 30.10.2018

accepted 09.08.2019

Bibliography

DOI <https://doi.org/10.1055/a-1010-6505>

Published online: 2019

Phys Med Rehab Kuror

© Georg Thieme Verlag KG Stuttgart · New York

ISSN 0940-6689

Correspondence

Dr. Muhammad Kashif

Riphah College of Rehabilitation Sciences

Riphah International University

Satiana Road

38000 Faisalabad

Pakistan

kashif.shaffi@gmail.com

ABSTRACT

Objective The objective of this study was to assess school backpacks and associated problems across school going children aged 8–12 years in Lahore, Pakistan. Self-perceived pain related to bag pack use, correlation between self-reported pain and perceived weight of bag pack, duration of bag pack carriage and the method of bag pack carriage were evaluated.

Methodology A cross-sectional survey was conducted on 3500 students from different private schools across Lahore. Both male and female students from the age of 8–12 years that were present on the day of the study with no apparent physical deformity or any musculoskeletal disorder were included in the study. Questionnaire used in this study was a modified questionnaire from a previous study.

Data collected through questionnaire was coded into SPSS version 18.

Data was represented in the form of graphs, tables, cross tabs and bar charts. Chi square test of association was applied with p value < 0.05 considered as significant.

Results The results indicate that 82 % of students surveyed carry bag packs, 54.66 % of the students perceived the weight of their bag pack heavy, 40.22 % medium while only 5.12 % reported their bag pack lightly weighed. Pain was higher in individuals who perceived their bag pack weight heavy (i. e., 48 % pain, who carried their bag pack for over 20 min (44 % pain and over 30 min (56 % pain, respectively. Similarly percentage of pain was higher in individuals who carried their bag pack at one shoulder (i. e., 74 % pain).

Conclusion The results of the present study show that there is a relationship between bag pack use, duration and method of bag pack carriage this suggests that heavy, medium and light bag packs may have damaging effects for the school going children. A study to compare children who follow and that do not follow the recommended guidelines should be conducted to find out the guidelines could help reduce back pain, the bag pack guidelines have addressed bag pack weight and duration of carriage should be considered.

ZUSAMMENFASSUNG

Ziel Mit dieser Studie sollte der Zusammenhang zwischen dem Tragen eines Schulrucksacks und körperlichen Beschwerden bei Schulkindern im Alter von 8–12 Jahren in Lahore, Pakistan, beurteilt werden. Untersucht wurden die subjektiv wahrgenommene Stärke der Rückenschmerzen in Zusammenhang mit dem Tragen des Rucksacks sowie der Zusammenhang zwischen subjektiver Stärke der Rückenschmerzen und subjektiv wahrgenommenem Gewicht des Rucksacks, der Tragedauer und der Handhabung beim Tragen.

Methoden Es wurde eine Querschnittsstudie mit 3500 Schülern unterschiedlicher Privatschulen in Lahore durchgeführt. In die Studie eingeschlossen waren Schülerinnen und Schüler im Alter von 8–12 Jahren, die am Durchführungstag der Studie anwesend waren und nicht unter einer körperlichen Fehlbildung oder Erkrankung des Bewegungsapparats litten. In dieser Studie wurde ein modifizierter Fragebogen aus einer früheren Studie verwendet. Die mittels Fragebogen erhobenen Daten wurden in SPSS Version 18 eingegeben. Die Daten wurden in Form von Graphiken, Tabellen, Kreuztabellen und Balkendiagrammen dargestellt. Ausgewertet wurde mittels

Chi-Quadrat-Test und bei einem p-Wert $< 0,05$ wurde der Zusammenhang als signifikant eingestuft.

Ergebnisse Die Ergebnisse zeigen, dass 82 % aller Schulkinder einen Rucksack tragen, 54,66 % empfanden ihren Rucksack als schwer, 40,22 % als mittelschwer und nur 5,12 % gaben an, dass ihr Rucksack leicht sei. Schülerinnen und Schülern, die ihren Rucksack als schwer empfanden, gaben an, unter größeren Schmerzen zu leiden (48 %), ebenso Schulkinder, die ihren Rucksack länger als 20 Min trugen (44 %) und länger als 30 Min (56 %). Die Prozentzahl derer, die angaben, unter Schmerzen zu leiden, war größer, wenn der Rucksack einseitig auf einer Schulter getragen wurde (74 %).

Schlussfolgerung Die Ergebnisse dieser Studie zeigen einen Zusammenhang zwischen dem Tragen eines Rucksacks, der Dauer und Art des Tragens; schwere, mittelschwere und leichte Rucksäcke können eine schädigende Wirkung auf Schulkinder haben. Es sollte eine Studie durchgeführt werden, in der Kinder, welche die empfohlenen Richtlinien befolgen, mit solchen verglichen werden, die diese nicht befolgen, um festzustellen, ob durch diese Richtlinie Rückenschmerzen verringert werden können. In diesen Richtlinien wurde das Gewicht von Rucksäcken und die Tragedauer berücksichtigt.

Introduction

Back pain is a serious health problem in children of school age due to the increased use of heavy backpacks. Excessive weight that is directly or indirectly transmitted to spine is often associated with adult low back pain [1]. The health effects of carrying heavy backpacks are obvious, and concerns about the safety of student backpacks are high worldwide [2]. Several other mechanisms have been proposed for this effect such as excessive vertebral compression due to spinal loading, compensatory changes to balance heavy loads or muscle imbalance [3–6]. Adolescent spine differs from the adult spine in that it represents a structure that is developed in variable stages of growth. Adolescent spine has different periods of growth up to the age of 18 years and is completed at the age 24 years with full spinal maturity. The spine in adolescents is less resilient and adaptable than the spine in adults in the fast-growing phase [7]. Average bag pack weight varied from 15–40 % of the child's body weight in different studies across the UK [8]. A survey conducted in University of Surrey, UK reported the prevalence of neck, upper back and low back pain of 27, 18 and 22 %, respectively due to bag pack [8]. Negrini and Carobalona reported that the average daily loads of students over a week ranged from 22–27.5 % of the body weight with maximum up to 46.2 % [8]. The load carried over the juvenile spine should not exceed the safe limit of 10 % according to International Chiropractic Pediatric Association, American Occupational Therapy Association and American Academy of Orthopedic Surgeons, 15 % according to American Physical Therapy Association and 5–10 % according to American Association of Chiropractors [9]. The way the bag pack is carried may also be considered as a risk factor for spinal pain and injury. Bag pack carried over one shoulder or very low over the spine may change the static and dynamic postures as the body tries to compensate

posterior shifting of the center of mass [10]. A poorly worn backpack affects shoulder height and curvature of the spine, which can lead to back pain (girls are more affected than boys) and can reduce the cranio-cervical angle due to changes in the biomechanics of the shoulder and upper thoracic spine [11, 12]. Studies have recommended that schoolchildren be between 5 and 20 % of their body weight. However, another study found that wearing backpacks with 15 % body weight is too heavy to maintain the students' posture [2].

It is believed that the excessive burden of the backpack affects the physiological and biomechanical parameters of children, as energy cost or expenditure, posture, fatigue, contact pressure, gait, spinal curvature and compression, and pulmonary capacity [13, 14]. Some researchers assume that the use of heavy backpacks is possible contribute to high reports of back pain in children. The recent study found that the safe weight of the backpack, which should be worn by both male and female secondary school students, was 5.18 % of body weight and 4.91 % of body weight, respectively [1]. Many health associations have agreed that excessive weight of schoolbags within the recommended load limits of 10–15 % of a child's body weight leads to LBP. Moreover, researchers recommend that the backpack weight should not exceed 10 % of a student's body weight for all grades and ages [15–17]. Most of the studies that looked at the LBP and backpack association recommended that the maximum backpack load for schoolchildren should be 10–15 % of body weight [18].

In Pakistan, the literature research has so far revealed no study on back pain in school-age children and adolescents. There are no data available that describe the current use of school bags of schoolchildren in the countryside and its link with back pain. Lahore is a metropolitan city with population of 8.7 million. Almost

► **Table 1** Sociodemographic variables of participants.

Grades	Mean age in years	Mean height in meters	Mean weight in Kgs	Mean BMI in Kg/m ²	Mean Bag Pack weight in Kgs	% age of the Body Weight
4	10.64 (0.84)	1.27 (0.03)	32.01 (3.25)	19.84 (5.56)	8.45 (2.22)	26.4
5	11.51 (0.66)	1.31 (0.01)	33.45 (4.88)	19.49 (5.88)	8.12 (4.89)	24.2
6	12.69 (0.45)	1.34 (0.02)	34.75 (6.22)	19.35 (4.97)	9.23 (3.23)	26.56
7	13.52 (0.26)	1.38 (0.01)	36.22 (4.00)	19.01 (2.69)	8.45 (2.25)	23.32
8	14.45 (0.56)	1.40 (0.01)	39.45 (5.28)	20.12 (3.65)	9.45 (3.36)	23.95

40% of its inhabitants are below the age of 15 and more than 3.5 million elementary school children carry books bags on their shoulder 5 days in a week for the entire school year. This is a significant issue that needs to be addressed as this problem has been reported internationally.

Methodology

Study design

This study was an observational cross sectional study conducted from September 2017 to August 2018 at different primary schools across Lahore, Pakistan. The timing of the survey was dictated by the participating school.

Participants

List of all the private schools in Lahore district registered with all Punjab Private School and College Association (APPSCA) was obtained. Name of each school was listed on a piece of paper and placed in box. A random sample of 10 private schools was drawn from the box (without replacement), that were to be included in the study. The details of the schools that were to be included in the study were obtained from and were sent an invitation letter and consent form to the head of institution for participation in the study. Out of 10 schools initially sampled, seven head of institute responded positively with their total number of students in school and number of students enrolled in each class.

Sample selection and sampling technique

A total of 3500 male and female students studying in the seven private schools across Lahore were enrolled in the study. Both male and female students from the age of 8–12 years that were present on the day of the study with no apparent physical deformity or any musculoskeletal disorder were included in the study. Students having any systemic illness like fever, cold, flu, malaise or using trolley bags or any other mode of carrying books other than shoulder bag packs were excluded from the study.

Data collection procedure and data collection tool

Questionnaire used in this study was modified from a previous study by Grimmer & William [4]. The questionnaire designed to collect demographic information of the children included their age, height, weight and body mass index (BMI). Height was measured

► **Table 2** Association of Gender with weight, time and method of back pack carriage.

	Female	Male	p-value
Perceived Weight of the Bag Pack			
Heavy	56.99	52.6	0.00
Medium	38.21	40	
Light	4.8	7.4	
Minutes of Bag Pack Carriage			
< 10	14.3	12.1	0.02
10–19	19.77	32.47	
20–29	41.32	28.33	
> 30	24.61	27.1	
Method of Bag Pack Carriage			
One Shoulder	9.56	13.65	0.05
Both Shoulder	89.23	78.65	
Others	1.21	7.79	
Area wise distribution of pain			
Pain	41.36	34.65	0.05
Low Back Pain	39.66	28.69	0.00
Muscle Soreness	26.21	19.36	0.41
Upper Back Pain	9.56	11.68	0.00
Neck Pain	6.89	4.32	0.09
Leg Pain	4.02	3.36	0.30
Arm Pain	16.35	18.36	0.01

with a steel tape in meters up to 0.01m. Students were instructed to stand erect with their spine erect, chest broad and chin tucked in for accurate measurement. Weight of the students, and the bag pack they were carrying was calculated using an electronic scale that measured with accuracy of 0.01 kg. The students stepped onto the weighing scale twice; once without bag pack and other with bag pack carried over their shoulder. Height and weight calculated was combined to calculate BMI using formula $\text{weight}/\text{height}^2$. Other questions inquired about the self-perceived weight of the bag pack (light, medium or heavy), minutes of bag pack carriage (< 10, 10–19, 20–29 and > 30 min), and method of bag pack car-

riage (one shoulder, both shoulder and any other). Two questions were used to record the perception of pain. One was generalized which students circled yes or no to the question that inquired about the pain while carrying the bag pack. The second provided a list of specific types of symptoms (muscle soreness, lower back pain, neck pain, tingling in arms/legs, upper back pain, leg pain, arm pain, other) for the student to check. The questionnaires from the schoolchildren were filled at early morning of the school time.

Data analysis

Data collected through questionnaire was coded into SPSS version 18. Data was represented in the form of graphs, tables, cross tabs and bar charts. Chi square test of association was applied with p value <0.05 being significant.

Results

Over all the sample of n = 2879 represented 82.26 % of the total population initially sampled. Almost 17.74 % (n = 611) subjects were lost because either they were absent on the day the study was conducted, change in the students timetable rendering students unavailable, or some used trolley bag as mode of carrying their study material.

Descriptive information regarding the age, weight, BMI and bag pack weight is summarized in ► **Table 1**. Bag pack weight percent-

age of body weight was calculated by dividing the bag pack weight with body weight of the student. It ranged from 26.40–23.95 % from grade 4–8 with maximum in lower grades. This indicates the average weight that the students carry every day over their shoulders is far above the normal recommended weight of 10 % [9].

Perceived weight of bag pack, duration of bag pack carried and method of bag pack carriage are significantly different by gender and grade as described in ► **Table 2**. About 54.66 % of the students perceived the weight of their bag pack heavy, 40.22 % medium while only 5.12 % reported their bag pack lightly weighed. There was significant association between the gender and the perceived weight of the bag pack with both females (56.99 %) and males (52.60 %) perceived their bag pack weight heavy, minutes of bag pack carriage with (41.32 %) of females and (28.33 %) of males, (89.23 %) females and (78.65 %) males with method of bag pack carriage. 12 % carrying their bag pack for less than 10 min, 16 % carried it to 10–19 min, 25 % carried it 20–29 min and 46 % greater than 30 min.

Results indicate that grade and gender were significantly associated with pain, low back pain, upper back pain and arm pain (► **Table 3**). Female shows (41.36 %) while male (34.65 %) of pain. Percentage of pain was higher in grade 4th, 6th, 7th and grade 8th students and less in grade 5th. ► **Table 4** shows the relationship of perception of bag pack weight, perceived duration of bag pack carriage and method of bag pack carriage to perception of pain and

► **Table 3** Association of Grades with weight, time, methods of back pack carriage and area wise distribution of pain.

	Grades					p-value
	% of 4 th	% of 5 th	% of 6 th	% of 7 th	% of 8 th	
Perceived Weight of the Bag Pack						
Heavy	13.25	44.69	47.58	49.65	50	0.00
Medium	61.2	44.28	30.56	29.33	28.36	
Light	25.55	11.03	21.86	21.02	21.64	
Minutes of Bag Pack Carriage						
< 10	31.66	23.46	29.2	32	27.14	0.00
10–19	38.31	41.24	39.21	40.02	32.41	
20–29	25.77	26.98	20.12	17.61	34.13	
> 30	4.26	8.32	11.47	10.37	6.32	
Method of Bag Pack Carriage						
One Shoulder	18.69	10.23	8.8	19.61	8.65	0.00
Both Shoulder	68.25	88.01	87.32	74.56	90.23	
Others	13.06	1.76	3.88	5.83	1.12	
Area wise distribution of pain						
Pain	31.28	19.45	38.44	41.29	33.45	0.00
Low Back Pain	19.56	17.44	29.02	33.49	30.78	0.01
Muscle Soreness	11.81	9.69	10.45	20.2	27.22	0.10
Upper Back Pain	12.77	3.35	6.69	7	4.38	0.00
Neck Pain	7.89	8.44	10.58	6.58	14.32	0.11
Leg Pain	3.23	2.25	1.58	4.36	5.77	0.54
Arm Pain	9.45	7.32	5.58	10.68	14.32	0.04

► **Table 4** Association of weight, time and method of back pack carriage with different areas of body pain.

Perceived Backpack Weight	Heavy	Medium	Light		P- value
Pain	48.65	32.00	09.35		0.00
Low Back Pain	47.59	31.23	11.56		0.00
Muscle Soreness	32.11	28.65	09.98		0.20
Upper Back Pain	33.80	21.55	08.82		0.00
Neck Pain	14.45	15.54	05.88		0.00
Leg Pain	09.56	06.88	02.23		0.10
Arm Pain	18.96	15.56	2.94		0.00
Method of Backpack Carriage	One Shoulder	Both Shoulder	Other		
Pain	74.88	65.32	8.65		0.00
Low Back Pain	55.68	47.23	3.56		0.00
Muscle Soreness	52.23	35.56	5.32		0.11
Upper Back Pain	82.55	42.25	6.65		0.00
Neck Pain	65.00	29.18	4.25		0.00
Leg Pain	28.25	12.28	8.65		0.10
Arm Pain	29.33	16.35	1.48		0.00
Perceived Duration of Backpack Carriage	< 10 min	10–19 min	20–29 min	> 30	
Pain	12.25	14.65	44.55	56.25	0.06
Low Back Pain	10.56	26.23	38.12	58.65	0.01
Muscle Soreness	09.25	14.23	24.32	34.25	0.00
Upper Back Pain	04.22	10.56	20.09	28.55	0.03
Neck Pain	06.69	11.33	25.01	30.86	0.64
Leg Pain	01.35	07.36	14.39	20.24	0.45
Arm Pain	02.78	11.58	21.33	36.10	0.00

related symptoms. Pain was higher in individuals who perceived their bag pack weight heavy (i. e., 48 %) pain, who carried their bag pack for over 20 min (44 %) pain and over 30 min (56 %) pain, respectively. Similarly percentage of pain was higher in individuals who carried their bag pack at one shoulder (i. e., 74 %) pain.

Discussion

The incidence of back pain and neck pain was about 50 and 53 % of the females report neck pain compared with the 44 % of males. Nearly, half subjects were carried their school bag for more than 30 min per day with the 85 % carried bag pack on the both shoulders. School bags were reported to be heavy by 54 % and they did cause exhaustion reported by 51 %. For more than 30 min carrying a school bag every day and travel through stationary form of the transport to school either by car or bus increased the probability of having both back and the neck pain. Among the adolescents neck pain is as common as back pain. Apparently the burden on the school bags, the length of carrying the bags and transport to school were related to back and neck pain [19].

Even if the typical loads differ significantly between the studies, the majority of the reports revealed that the loads carried by the

students are greater than the suggested range [4, 20–24]. Due to this weight over the adolescent spine it has been taken as a strong risk factor for developing different musculoskeletal problem among children [16]. According to American Occupational Therapy Association stated that bag pack strap pressure can compress the blood vessels and the nerves in the shoulder and neck. This pressure can result in pain and the tingling in arms, hands, legs and neck. Straps should be padded properly to prevent too much pressure. The contact pressure under the shoulder strap was considerably greater at the right shoulder than of the left shoulder at 10, 20, and 30 % of the body weight [25]. Although musculoskeletal problems are believed to have multiple factors in origin, the carriage of heavy schoolbags is supposed to be causative factor and may represent an unnoticed daily physical stress [26].

Studies have indicated that both the bag pack weight [27] and the duration of time [28] carried bag pack may affect both the cervical and the shoulder posture [29]. Another study concluded that low back pain was not significantly related with physical activity but found strong association with daytime fatigue and other emotional factors. Results also recommend that the psychosocial factors relatively than the mechanical factors were more important in the low back pain occurring in the young population and could might be an

indication of distress in the school going children [30]. Asymmetrical bag pack carrying was correlated with the back pain. The change in posture and trunk movement and position during transport of the backpack was highly correlated, which also affected the adolescent's respiratory mechanics. Forward flexion due to an excessive trunk limits trunk movement, which appears to affect thorax movement, and appears to decrease the size of the abdomen as the muscles contract to increase stability and prevent abdominal breathing [31]. A systematic review conclude that a backpack load of 10% of bodyweight would be safer for the spine of schoolchildren. Care should be taken to relieve the spine of schoolchildren in building a healthier and painless society in the future [18].

Limitations

The etiology of back pain in schoolchildren was not investigated in this study. In addition, the psychosocial factors that may be the cause of low back pain in schoolchildren were not measured in this study, which is one of the limitation of this study. Moreover, the study does not include a comparison of children who follow and who do not follow the guidelines.

Conclusion

The results of the present study indicate that the bag pack used, duration and method of bag pack carriage are associated with adolescent pain in different parts of the body. The bag pack guidelines which have addressed bag pack weight and duration of bag pack carriage should be considered.

Recommendation

The Pakistani population especially parents should be aware about the recommended and safe load limits between 10% and 15% of the body weight of schoolchildren. A study to compare children who follow and that do not follow the recommended guidelines should be conducted to find out the guidelines could help reduce back pain.

Conflict of Interest

Authors declare that they have no conflict of interest.

References

- [1] Ismaila S. Safe backpack weight limit for secondary school students in Ibadan, Southwestern Nigeria. *Alexandria Engineering Journal* 2018; 57: 547–554
- [2] Mosaad DM, Abdel-Aziem AA. Backpack carriage effect on head posture and ground reaction forces in school children. *Work* 2015; 52: 203–209
- [3] Burton KA, Clarke RD, McClune TD et al. The natural history of low back pain in adolescents. *Spine* 1996; 21: 2323–2328
- [4] Grimmer K, Williams M. Gender-age environmental associates of adolescent low back pain. *Applied Ergonomics* 2000; 31: 343–360
- [5] O'Sullivan P. Diagnosis and classification of chronic low back pain disorders: maladaptive movement and motor control impairments as underlying mechanism. *Manual Therapy* 2005; 10: 242–255
- [6] Kashif M, Kompal R, Riaz U et al. Prevalence of low back, neck and shoulder pain and associated risk factors among senior semester female students of the university of faisalabad. *Int J Rehabil Res* 2017; 5: 21–27
- [7] Cheng JC, Castelein RM, Chu WC et al. Adolescent idiopathic scoliosis. *Nature Reviews Disease Primers* 2015; 1: 15030
- [8] Rai A, Agarawal S. Back problems due to heavy backpacks in school children. *IOSR Journal Of Humanities And Social Science (IOSR-JHSS)* 2013; 10: 01–05
- [9] Cavallo CM, Hlavaty TM, Tamase MGM. A pilot study for the development of a primary prevention program: What is the average weight of a fourth grader's backpack? *Work* 2003; 20: 137–158
- [10] Singh T, Koh M. Effects of backpack load position on spatiotemporal parameters and trunk forward lean. *Gait & Posture* 2009; 29: 49–53
- [11] Yamato TP, Maher CG, Traeger AC et al. Do schoolbags cause back pain in children and adolescents? A systematic review. *Br J Sports Med* 2018; 52: 1241–1245
- [12] Minghelli B, Oliveira R, Nunes C. Postural habits and weight of backpacks of Portuguese adolescents: Are they associated with scoliosis and low back pain? *Work* 2016; 54: 197–208
- [13] Adeyemi AJ, Rohani JM, Rani MRA.. Backpack-back pain complexity and the need for multifactorial safe weight recommendation. *Applied Ergonomics* 2017; 58: 573–582
- [14] Adeyemi AJ, Rohani JM, Rani MA. Back pain arising from schoolbag usage among primary schoolchildren. *International Journal of Industrial Ergonomics* 2014; 44: 590–600
- [15] Mwaka ES, Munabi IG, Buwembo W et al. Musculoskeletal pain and school bag use: a cross-sectional study among Ugandan pupils. *BMC Research Notes* 2014; 7: 222
- [16] Moore MJ, White GL, Moore DL. Association of relative backpack weight with reported pain, pain sites, medical utilization, and lost school time in children and adolescents. *Journal of School Health* 2007; 77: 232–239
- [17] Macedo RB, Coelho-e-Silva MJ, Sousa NF et al. Quality of life, school backpack weight, and nonspecific low back pain in children and adolescents. *Jornal de Pediatria* 2015; 91: 263–269
- [18] Janakiraman B, Ravichandran H, Demeke S et al. Reported influences of backpack loads on postural deviation among school children: A systematic review. *Journal of Education and Health Promotion* 2017; 6
- [19] De Paula A, Silva J, Silva J. The influence of load imposed by the backpack school in children and teens in Brazil. *Procedia Manufacturing* 2015; 3: 5350–5357
- [20] Viry P, Creveuil C, Marcelli C. Nonspecific back pain in children. A search for associated factors in 14-year-old schoolchildren. *Revue du rhumatisme (English ed)*. 1998; 66: 381–388
- [21] Pascoe DD, Pascoe DE, Wang YT et al. Influence of carrying book bags on gait cycle and posture of youths. *Ergonomics* 1997; 40: 631–640
- [22] Negrini S, Carabalona R. Backpacks on! Schoolchildren's perceptions of load, associations with back pain and factors determining the load. *Spine* 2002; 27: 187–195
- [23] Sheir-Neiss GI, Kruse RW, Rahman T et al. The association of backpack use and back pain in adolescents. *Spine* 2003; 28: 922–930
- [24] Goodgold S, Corcoran M, Gamache D et al. Backpack use in children. *Pediatric Physical Therapy* 2002; 14: 122–131
- [25] Macias BR, Murthy G, Chambers H et al. High contact pressure beneath backpack straps of children contributes to pain. *Archives of Pediatrics & Adolescent Medicine* 2005; 159: 1186–1188
- [26] Whittfield J, Legg S, Hedderley D. Schoolbag weight and musculoskeletal symptoms in New Zealand secondary schools. *Applied Ergonomics* 2005; 36: 193–198

- [27] Young IA, Haig AJ, Yamakawa KS. The association between backpack weight and low back pain in children. *Journal of Back and Musculoskeletal Rehabilitation* 2006; 19: 25–33
- [28] Grimmer KA, Williams MT, Gill TK. The associations between adolescent head-on-neck posture, backpack weight, and anthropometric features. *Spine* 1999; 24: 2262
- [29] Chansirinukor W, Wilson D, Grimmer K et al. Effects of backpacks on students: measurement of cervical and shoulder posture. *Australian Journal of Physiotherapy* 2001; 47: 110–116
- [30] Watson KD, Papageorgiou A, Jones GT et al. Low back pain in schoolchildren: the role of mechanical and psychosocial factors. *Archives of Disease in Childhood* 2003; 88: 12–17
- [31] Vieira AC, Ribeiro F. Impact of backpack type on respiratory muscle strength and lung function in children. *Ergonomics* 2015; 58: 1005–1011