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Effect of backpack load on nerve conduction velocity and risk of peripheral neuropathy in upper extremities of undergraduate medical students carrying backpack

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ABSTRACT

Background: Prolonged load carriage can potentially affect hand and upper limb use through compression of the nerves, reduction in blood flow, and muscle fatigue. Backpacks of undergraduate medical student are not much different from their syllabus. They carry heavy backpacks on regular basis and many times they wear it incorrectly. **Aims and Objectives:** We aimed to see the effect of backpack load on motor nerve conduction velocity and hand grip strength in the upper extremities. **Materials and Methods:** The present study included 31 undergraduate medical students between the age of 18 and 25 years. The procedure is conducted in three phases on different days. In each phase, participants were asked to walk for 5 min with load. In Phase 1, nerve conduction velocity and grip strength weere measured in unloaded condition and after carrying load <10% of body weight. To limit the effect of fatigue, participants are instructed to return to laboratory in next consecutive weeks to repeat the procedure for Phase 2 and 3 as in Phase 1 by increasing load to 10–20% and 20–30% of their body weight respectively. **Results:** Values of median and ulnar motor nerve conduction velocity obtained without and with increasing % of backpack load after 5 min walk were decreased non-significantly as load increased. There was significant (P>0.001) difference in grip strength of medical students carrying backpack with increasing load after 5 min walk. **Conclusion:** In this study, we aimed at quantifying the effects of load carriage on overall upper limb performance, with a focus on conduction velocity of motor nerves. This has implications for occupations such as soldiers, firefighters, paramedics, and others who may be required to operate machinery, equipment, tools, or systems that require precise motor control.

Key words: Backpack load; Handgrip strength; Motor nerve conduction velocity; Peripheral neuropathy; UG medical students

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INTRODUCTION

Backpacks are easy and comfortable mode for carrying heavy goods on your back. Load carriage frameworks are utilized as devices for an assortment of Industrial, military, and educational circumstances.[1] Training exercises and operations frequently require troops to carry loads as heavy as 60% of body weight for prolonged periods of time while walking at a brisk pace.[2] From nursery children to soldiers, backpack is used to carry light to heavy weight goods, from books, occupational gears to what not! But are they actually as comfortable as they appear? School Bags are a major concern as we cannot assume that student's bodies react to shoulder stress in exactly the same way as adults. Differences in physiology could lead to different consequences, tolerance level, and damage level.

Backpacks worn incorrectly and overloaded for an extended period of time can cause upper-limb weakness, discomfort, and numbness. This weight has the potential

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to injure the brachial plexus, which contains the nerve supply to the arm. Over weight back packs worn for prolonged times and poor quality along with compromised physical health can cause significant disability at times. The kinematic effects of carrying a backpack include muscular imbalances, gait, postural changes, and spinal responses, as well as physiologic effects on metabolic cost, vital measures, brachial plexus function and even decreased brachial artery flow in subjects carrying heavier backpacks.[3] There is a widespread belief that repeated carrying of heavy loads, such as school backpacks, place additional stress on rapidly growing adolescent spinal structures, making them prone to postural change.[4] Moreover, external forces such as load carrying in the form of heavy bags may influence the normal growth, development of children and adolescents, and also maintenance of alignment of their bodies.[5] Backpack palsy is a well-recognized, albeit rare, and complication of carrying backpacks. Although it has been mostly described in cadets during strenuous training,[6] sporadic cases of brachial nerve impairment have been reported in children and young adults.[7] Rucksack Palsy Rucksack palsy is a disabling injury and has been widely reported in association with load carriage.[4,8] Prolonged load carriage can potentially affect hand and upper limb use through compression of the nerves, reduction in blood flow and muscle fatigue.[9,10] Students in primary, secondary, and tertiary education commonly use backpacks to carry their books and sporting equipment on a daily basis.[11] Many studies have been done on the effects of backpack load carriage on the lower body measures such as gait.[12] However, there have been few studies on the effects of backpack load carriage on the upper extremity function.[13,14]

Backpacks of undergraduate medical student are not much different from their syllabus. They carry heavy backpacks on regular basis and many times they wear it incorrectly. About 90% student's reside in hostel having almost 4–5 floors, so they have to carry backpack which includes books, notebooks, water bottles, etc. from hostels to different departments and hospital on daily basis by climbing upstairs in hostel as well as medical college for almost 20–30 min daily. No study has been taken place on the risk assessment of backpack palsy in undergraduate medical students. Therefore, this research work has been planned for assessing risk of backpack palsy in undergraduate medical students on nerve conduction velocity and grip strength by varying percentage of weight carried on their backpack. These researches will not only help in risk assessment but will also help in educating undergraduates about backpack palsy.

Aims and objectives

The current study aimed to observe the effect of backpack load on motor nerve conduction velocity and hand grip strength in the upper extremities.

MATERIALS AND METHODS

This is a prospective and interventional study. Participants filled tested questionnaire after giving them brief description about project and detail description of procedure and questionnaire. Before initiating the study, the permission from the Institutional Ethics Committee (IEC), GMC Ratlam was obtained. (GMC Ratlam/2020/IEC/approval/017 dated December 14, 2020).

After collecting the questionnaire, the procedure is conducted in three phases on different days. In each phase, participants were asked to walk for 5 min with load. In Phase 1, nerve conduction velocity and grip strength were measured in unloaded condition and after carrying load <10% of body weight. To limit the effect of fatigue, participants are instructed to return tolaboratory in next consecutive weeks to repeat the procedure for Phase 2 and 3 as in Phase 1 by increasing load to 10–20% and 20–30% of their body weight, respectively.

Study population and selection criteria

The study was conducted on undergraduate medical students of age group between 18 and 25 years. Written consent form was taken before investigation after detail information given to the participants regarding the study. In the present research, convenient sampling was used the students who are happy to be approached and become part of the research and also considering the time frame of the whole process. Sample size was 31 out of which 16 were girls and 15 were boys. Inclusion criteria – age group 18–25 years undergraduate medical students who are given their consent are included in study. Exclusion criteria – Subjects having relevant history of a fall, accidents, or other disease pertaining to soft-tissue injury or pain (i.e., rheumatoid arthritis, diabetes, and anemia) and any endocrinal disorder were excluded from the study.

Nerve conduction velocity and hand grip strength measurements

Motor nerve conduction velocity was performed by digital polygraph PTB4263 Power lab system (AD Instruments) and following parameters were assessed:

1. The median motor nerve latency was recorded with surface electrodes over the Abductor pollicis brevis muscle and stimulation at the wrist and elbow
2. The ulnar motor nerve response was recorded with surface electrodes over the hypothenar muscle and stimulation at the wrist and elbow
3. Hand Grip strength was assessed by hand grip dynamometer using digital polygraph PTB4263 Power lab system. (AD Instruments).

Statistical analyses

Statistical analysis was carried out using SPSS statistics (IBM Inc. version 20 for Windows) software.

RESULTS

Values of median motor nerve conduction velocity obtained in medical students without and with increasing % of backpack load after 5 min walk are shown in Table 1 and it was found that median motor nerve conduction velocity was decreased non-significantly as load increased.

Table 2 shows the values of ulnar motor nerve conduction velocity obtained in medical students without and with increasing % of backpack load after 5 min walk. No significant difference was found in median motor nerve conduction velocity as load increased.

There were significant difference in grip strength of medical students carrying backpack with increasing load with 5 min' walk which is shown in Table 3.

DISCUSSION

Backpack palsy brachial plexus palsy or backpack palsy results from carrying heavy loads with a backpack that leads to an occlusion of blood, compression of nerves leading to the upper extremities or a cervical vertebrae traction injury. Symptoms of pack palsy can include experiencing cramping, muscle weakness, scapular winging, and paralysis in the upper extremities.[1,9,10,15] The purpose of this study was to investigate the short-term effects of walking with heavy backpack load on the neuromuscular physiology of the upper limbs. The results show that the significant changes in median and ulnar motor nerve conduction velocity were not accompanied by changes in % of backpack load by walking with load for 5 min. Hand grip strength was significantly decreased in the present study by walking with increasing load carried by students which was similar to the study done by Jennifer et al. The previous results showed

Table 1: Comparison of median motor nerve conduction velocity depending on % of load they carried after 5 min walk

ANOVA	Sum of squares	df	Mean square	F	Sig.
Without load					
Between groups	4.327	1	4.327	0.207	0.652
Within groups	605.114	29	20.866		
Total	609.441	30			
>10% of backpack load					
Between groups	3472.376	1	3472.376	0.850	0.364
Within groups	118450.093	29	4084.486		
Total	121922.469	30			
10–20% of backpack load					
Between groups	6.304	1	6.304	0.509	0.481
Within groups	358.869	29	12.375		
Total	365.173	30			
20–30% of backpack load					
Between groups	0.870	1	0.870	0.034	0.855
Within groups	742.108	29	25.590		
Total	742.978	30			

Table 2: Comparison of ulnar nerve conduction velocity depending on % of load they carried after 5 min walk

ANOVA	Sum of squares	df	Mean square	F	Sig.
Without Load					
Between groups	0.030	1	0.030	0.003	0.955
Within groups	270.450	29	9.326		
Total	270.480	30			
>10% of backpack load					
Between groups	0.281	1	0.281	0.039	0.846
Within groups	211.269	29	7.285		
Total	211.550	30			
10–20% of backpack load					
Between groups	1.315	1	1.315	0.122	0.729
Within groups	312.393	29	10.772		
Total	313.707	30			
20–30% of backpack load					
Between groups	1.664	1	1.664	0.123	0.728
Within groups	392.318	29	13.528		
Total	393.982	30			

Table 3: Comparison of hand grip strength depending on increasing % of load they carried after 5 min walk

ANOVA	Sum of squares	df	Mean square	F	P-value (>0.001=significant)
Without load					
Between groups	297263.232	1	297263.232	65.788	0.0001
Within groups	131037.548	29	4518.536		
Total	428300.780	30			
>10% of backpack load					
Between groups	264438.091	1	264438.091	69.035	0.0001
Within groups	111084.497	29	3830.500		
Total	375522.588	30			
10–20% of backpack load					
Between groups	267054.765	1	267054.765	60.662	0.0001
Within groups	127667.949	29	4402.343		
Total	394722.714	30			
20–30% of backpack load					
Between groups	200287.093	1	200287.093	46.615	0.0001
Within groups	124602.694	29	4296.645		
Total	324889.787	30			

the short-term effects of walking with heavy backpack load on the biomechanics and the physiology of the upper limbs and found that several physiological measures were affected by walking with a backpack load.[16] Motor nerve conduction is an important electrodiagnostic procedure for evaluation of structural and function integrity of motor neurons. The latency of compound muscle action potential (CMAP) indicates the speed of conduction in nerves, whereas the amplitude of CMAP refers to the density of nerve fibers and the muscle mass activated by stimulation of the motor nerve.[17] The conduction velocity of the nerve depends on the fiber diameter, degree of myelination, and the internodal distance. As the axon increases in size, the myelin sheath becomes thicker, and the internodal distance becomes longer. The conduction, therefore, becomes faster, In the previous research done by Kim et al.,[2] blood flow in upper extremity was significantly reduced to 43% of base line blood flow volume after 10 min of standing with a 12 Kg weight and to a 57% of baseline after 15 min standing with backpack load of 40%. Hadid et al., 2013.[14] which indicates that as backpack load as well as duration of carriage increases, blood flow decreases due to external compression force on shoulder which can also affect the brachial plexus too due to compression force as well as blood supply to nerve nerves may get reduced. Nerve roots compression may lead to weakness, numbness and pain where the nerve travels. The pain may be felt as deep, dull, and achy or may have sharp shooting pain along the path of the nerve. Muscles controlled by the affected nerve root may also be weakened.[18]

In the present study, motor conduction tests of the upper limb revealed that there was non-significant increase in latency of CMAP of median and ulnar nerve with decrease in mean conduction velocity of both the nerve in medical students carrying load with increasing % of backpack load with 5 min walk. Non-significant decrease in motor nerve conduction velocity as % of backpack load increases could be due to duration of load; they carried may be too short, more importantly, use of a frame and hip belt has been demonstrated to reduce the incidence of rucksack palsy presumably by reducing pressure on the shoulders.[8] Hypothetical risk factors for rucksack palsy include heavy loads, load distribution, and longer carriage distances.[4,8] It is hypothesized that the shoulder straps of a backpack can cause a traction injury of the C5 and C6 nerve roots of the upper brachial plexus. In minor cases, compression results in entrapment of the long thoracic nerve. Symptoms include numbness, paralysis, cramping, and minor pain in the shoulder girdle, elbow flexors, and wrist extensors. Long thoracic nerve injuries usually present with "scapular winging" because of weakness of the serratus anterior muscle. Sensorimotor deficits from rucksack palsy injuries are usually temporary but, in some cases, may result in a chronic condition.[4,8] Researchers have suggested that blood flow occlusion, nerve compression, or a combination of both are the most likely mechanisms underlying the signs or symptoms of backpack palsy. Our result indicated that load carriage hampers the large myelinated nerve fiber nerve conduction. This might be attributed to deformation of the brachial plexus, resulting decreased nerve conduction velocities.[10,14]

Implication

This study will help to assess the effect of carrying backpack and on musculoskeletal system and to study relation between backpack wearing practice-habit and musculoskeletal discomfort. After loading backpack nerve, conduction velocity and grip strength in both upper limbs will decrease. Since backpack is been used since childhood by majority of undergraduates, it will also depend on the duration since which participant are using backpack. This study will help to creating awareness regarding ill effects of wearing heavy backpack.

Limitations of the study

We have not assessed body composition and the contribution of body fat percentage to the nerve conduction deficits. The gender difference in the conduction velocity has not been assessed.

CONCLUSION

In this study, we aimed at quantifying the effects of load carriage on neuromuscular parameters and the consequent effects on overall upper limb performance, with a focus on conduction velocity of motor nerves. The present study is the first to assess the physiological consequences of a hefty backpack's mechanical compression and deformations on the soft tissues of the shoulder. This has ramifications for professions such as soldiers, firefighters, paramedics, and others who may be required to operate machines, equipment, gadgets, or systems that require precise motor control. Furthermore, the innovative study design allowed for quantitative analyses of the impacts by utilizing modalities that investigated the influence of the load on numerous brain conductance circuits. As a result, the impacted capabilities as well as the (patho)physiological source of the impacts can be assessed.

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JCH- Concept and design of the study, prepared first draft of manuscript and revision of the manuscript; **AR**- Concept, reviewed the literature, and manuscript preparation; **SW**- Interpreted the results, coordination, preparation of manuscript, and revision of the manuscript; and **LK**- Statistical analysis and interpretation

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