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Original Research Article

The Effects of Backpack on Muscle Activity and Back Pain in Adolescents

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Abstract: The purpose of the study: To explore the impact of backpack on adolescent muscle activity, and the relationship between it and adolescent back pain, to provide theoretical basis for domestic scholars in this field of in-depth research. Research methods: Literature related to backpack, muscle activity and back pain were searched, and the research results were analyzed. Results: The studies mainly focused on the effects of backpack type a nd mode on muscle activity, while few reports focused on the location and walking time of backpack. The main muscles studied were the upper trapezius muscle, the erector spinalis muscle and the rectus abdominis muscle, while the other muscles were not studied enough. Conclusion: The type and way of backpack, the weight of backpack, the design of backpack strap, the position of backpack and the time of backpack all have different degrees of influence on the muscle activity of various parts of teenagers, and these effects may lead to back pain, which is one of the factors that cannot be ignored.

Keywords: Backpack, muscle activity, electromyography, back pain, spine health.

INTRODUCTION

Backpacks are an essential item in the lives of most people nowadays. Over the past 20 years, the burden of backpacks on young people has gradually increased, which many doctors believe may have harmful effects on their physical health (Al-Kha bbaz *et al*., 2008). In today's society, the incidence of various spinal diseases related to the cervical and lumbar vertebrae has increased greatly compared with the past. Such spinal diseases often cause back pain, muscle soreness and other problems. Low back pain has become a growing concern among young people. 40% of young people aged 9 to 21 in the world report that they suffer from low back pain (Calvo *et al*., 2013), which is closely related to people's use of backpacks. At present, there have been a lot of studies on the impact of backpacks on human body in foreign countries, while domestic studies on this aspect are still insufficient. Many scholars have conducted studies on the way, weight and type of backpacks to explore the impact of backpacks on spinal shape, muscle activity, gait and planar pressure. This article mainly summarizes and analyzes the research results of domestic and foreign scholars from the aspect of the impact of backpack on human muscle activity, aiming to provide theoretical basis for domestic scholars in the field of in - depth research.

1. Research Methods

This paper mainly adopts the literature data method to obtain relevant literature data. CNKI, web of science electronic journals, and Google Academic search engine were searched for relevant literature by computer, with "backpack, school bag, muscle activity, back pain, electromyography" as the main Chinese search keywords. Backpack, schoolbag, muscle activity, EMG were the main search keywords in English, and the time was set from 1985 to 2020. Preliminary review of the data, select the article structure is more complete, the research method is more clear, the research content and "backpack, muscle activity, back pain" closely related literature data, and roughly according to different research directions to sort out: the study of spine shape and study of back pain data were classified, and further according to different backpack ways and backpack weight for detailed classification.

2. The influence of backpacks on human muscle activity

At present, foreign scholars on the impact of backpack on muscle activity, mainly from the aspects of backpack type, shoulder strap design, backpack position, backpack weight, etc. A small number of studies also start from the time, on the erector spine muscle, sternocleidomastoid muscle, trapedus muscle, paravertebra muscle, rectus abdominis muscle, external oblique abdominis muscle, Latissimus dorsi, vastus medialis, biceps femoris and other muscles of back,

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neck, abdomen and lower limbs were studied. The most extensively studied muscles are the erector and trapezius muscles, which have been chosen by a large number of scholars because the erector is thought to be associated with degenerative disc disease (Chaffin *et al*., 1969), while the trapezius muscles have been shown to be very sensitive to changes in weight -bearing conditions (Bobet, Norman *et al*., 1982). This paper summarized, summarized and analyzed the researches of foreign scholars from the aspects of backpack type, backpack mode, backpack weight and walking time.

2.1 The influence of knapsack type and knapsack mode on muscle activity

Most people have different ways of carrying a backpack. The different ways of carrying a backpack are reflected in the choice of the type of backpack and the use of different backpack straps, and the different types of backpack and backpack straps will have an impact on human muscle activity.

2.1.1 The impact of the type of backpack on muscle activity

From the perspective of the type of backpack, a large number of foreign studies have conducted research on this, and the type of backpack has been proved to be one of the important factors affecting the muscle activity when the human body is carrying a backpack. Relevant studies have explored the relationship between the muscle activity and the type of backpack during walking. The results showed that the muscle activities of right upper trapezius, left upper trapezius, right erector spinus and left erector spinus were significantly higher when walking with a single shoulder bag than when walking with a backpack (Jung *et al*., 2014). In addition, other studies have also obtained similar results, when people walk with a backpack, the type of backpack has a significant impact on muscle activity. It also follows that carrying a backpack is a better way to carry a backpack than carrying a single shoulder bag (Hell *et al*., 2020). In the case of unilateral loading, trapezius muscle activity is significantly increased and pectoralis major muscle activity is significantly decreased, but the trapezius muscle activity is significantly stronger on one side than the other, and the degree of reduction in pectoralis major muscle activity is not the same on both sides (Schulue *et al*., 2013). It can be concluded that wearing a shoulder bag will not only cause more significant changes in muscle activity, but also make both sides of the muscle activity unbalanced. The type of backpack with a backpack bag is better than that with a shoulder bag.

For the influence of different types of backpacks on muscle activity, Kim *et al*., designed three different types of backpacks, which are: 1. No backpack; 2. Ordinary backpack; 3. Double backpacks (with two identical backpacks before and after); 4. Modified double backpacks (10% and 5% of body weight, respectively), as shown in Figure 1. It was found that myoelectric activity in the upper trapezius muscle was significantly increased when carrying a normal backpack, a double backpack, and a modified double backpack compared to walking without a backpack. However, the electromyoelectric activity of sternocleidomastoid muscle when carrying the modified double backpack was significantly lower than that of the ordinary backpack or the double backpack, and there was no significant difference from that of the sternocleidomastoid muscle without the backpack. Motman *et al*., also conducted a similar study, but found that there was no significant difference between EMG and no backpack when wearing a double backpack with uniform front and back weight, which was different from Kim's research results. However, it can be shown that both the double backpack with uniform front and back weight and the improved double backpack have a smaller impact on muscle activity than ordinary backpack. In addition, the improved double backpack can not only weaken the muscle activity of sternocleidomastoid muscle, but also have a smaller impact on body posture than other backpacks. It can be seen that muscle activity is closely related to body posture.

Figure 1: Three different types of backpacks (Kim *et al*., 2008)

Related studies have also studied the impact of hanging backpacks on the human musculoskeletal system. The hanging backpacks used in the study can move relative to the human back during walking, as shown in Figure 2. The experimental results show that compared with ordinary backpacks, wearing a suspension backpack can reduce the muscle activity of the soleus and tibialis anterior muscles, but increase the muscle activity of the upper trapephalus muscle, which may cause more stress on the shoulder, which may be due to the movement of the backpack relative to the back will lead to decreased shoulder joint stability. Thus resulting in increased activity of the upper trapezius muscle, which provides shoulder stability (Huang *et al*., 2020).

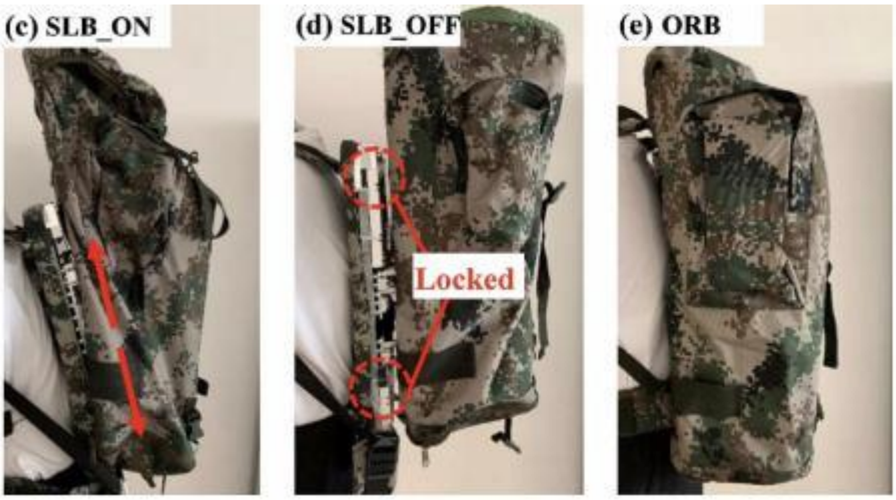

Figure 2: Suspension Backpack (Huang *et al*., 2020)

Foreign scholars have never stopped the improvement of backpacks. Ramadan et al. designed a backpack similar to a life jacket. This improved backpack divides the backpack into two parts to distribute carry-on items, as shown in Figure 3. The first part is placed on the student's chest, and the second part is placed on the student's back. There are two small pockets on the chest and one large pocket on the back. Studies have shown that this life-jacket backpack can reduce the activity of the rectus abdominis muscles a nd the muscles around the spine, helping to reduce stress on the back muscles, compared to the average backpack. In addition, the other backpack is designed with a total of three pockets, as shown in Figure 4. On the basis of the original backpack, two pockets are added to the sides of the backpack, as the idea of side pockets is considered to distribute the concentrated weight of the back (AbdelAziem *et al*., 2018), and two straps are added to the backpack (Ramada *et al*., 2020).

Figure 3: Lifejacket type backpack (Ramada *et al*., 2020)

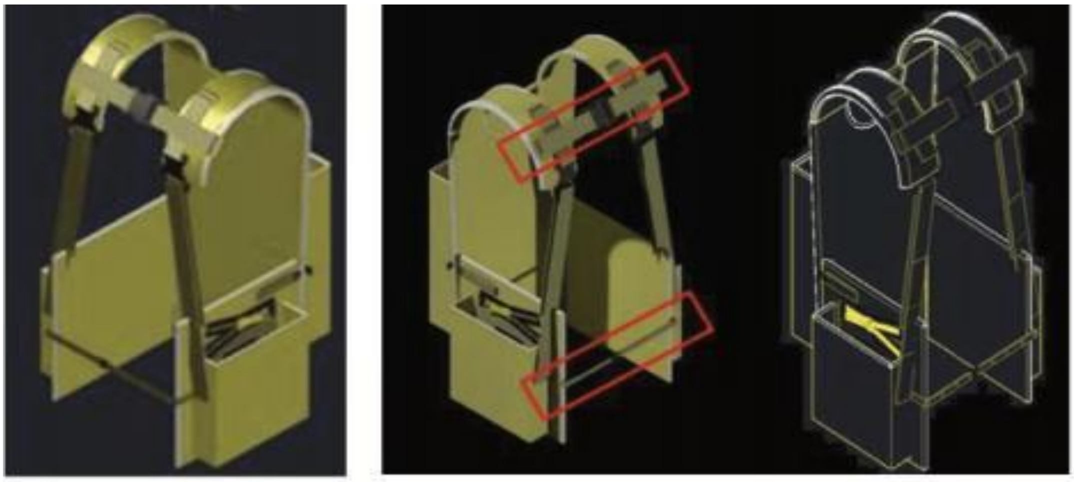

Figure 4: New and improved backpack (AbdelAziem *et al*., 2018)

2.1.2 Influence of knapsack mode on human muscle activity

Chen *et al*., conducted a study on three different ways of carrying a backpack (double-sided backpack, single-sided backpack and crossbody backpack), and the results showed that different ways of carrying a backpack had significant effects on trapedus muscle activation and body posture, among which the one-sided backpack mode was compared with the other two modes. The degree of shoulder tilt and the degree of trunk curvature, and the muscle activity of the upper trapedus muscle were significantly higher than those of the other two knapsack modes. There are many similar studies. Female college students were asked to use crossbody backpack and unilateral backpack to record the EMG of the upper trapezius muscle, supraspinatus muscle and latissimus dorsi muscle. The results showed that there was no significant difference in the EMG of latissimus dorsi muscle under the two backpack methods, and the same results were obtained in the upper trapezius muscle, supraspinatus muscle and erector ridge muscle. There are significant differences in muscle activity under different knapsack modes, and unilateral knapsack can cause significant changes in muscle activity on one side (Cho *et al*., 2013, Hardie *et al.*, 2015). To sum up, compared with other knapsack modes, unilateral knapsack will cause significant changes in some muscle activities, and the muscle activities on both sides are unbalanced. Relevant studies do not recommend the use of unilateral knapsack mode. Such changes are most likely caused by changes in body posture caused by unbalanced load, which will lead to body strain.

2.2 The influence of different backpack straps on muscle activities

As for the study of backpack straps, Jung *et al*., conducted a study on the length of backpack straps, and the results showed that there was no significant correlation between the length of backpack straps and muscle activity. The same conclusion was reached by Hell *et al*., However, even if there is no significant correlation between strap length and muscle activity, it does not mean that backpack straps have no effect on muscle activity. Many scholars have found that other aspects of straps also have an impact on muscle activity

Traditional backpack straps are flexible, and it is this flexibility that allows the backpack to move freely on the person's back when in use, and Mohammadreza *et al*., proposed a new design for non-flexible backpack straps that are not bendable. The vast majority of participants in the study found that the new non-bendable strap reduces discomfort in the neck, shoulder, and lower back muscles while carrying a backpack.

Kim *et al.,* examined the effects of backpack strap spacing on neck muscle activity and upper trapezius muscle pain in 14 men. Compared with narrow- spaced shoulder straps, wide-spaced shoulder straps had significantly lower neck muscle activity and upper trapezius pressure pain thresholds, and significantly increased acromial Angle. Backpacks with narrower strap spacing can lead to scapular disease and chronic upper trapezius pain, so a backpack with a wider strap spacing should be used when packing.

2.3 Influence of different position of backpack on muscles

According to the literature reviewed so far, the main research direction focuses on the type and weight of knapsack, and there are few studies on the influence of knapsack position on muscle activity. Bobet et al. studied the effects of two types of backpack position on muscle activity, which were slightly lower than the middle of the back and slightly higher than the shoulder, and the results showed that when the backpack position was slightly higher than the shoulder, it would cause more intense muscle activity. Wearing a normal backpack significantly reduced the activity of the erector spine muscle, while wearing a front-mounted backpack significantly increased the activity of the erector spine muscle, which also proves that the position of the backpack can affect the muscle activity (Motman).

2.4 Effects of backpack weight on muscle activity

Knapsack weight is currently one of the hot spots for domestic and foreign scholars to study knapsack weight. There are a large number of literatures at home and abroad to study knapsack weight. All relevant studies show that knapsack weight has a significant impact on human muscle activity.

Bauer *et al*., 's study aimed to find a reasonable maximum for middle school students to carry backpack weight. By asking 20 subjects to carry 0% to 20% of their body weight on a treadmill, they found that there was no significant difference in muscle activity between 0% and 10% BM, while there was a significant difference between 10% and 15% BM. Thus, the maximum possible weight was 10% BM.

When measuring changes in muscle activity of latissimus dorsi and erector spinal muscles under different weights, there was no significant difference in the EMG of latissimus dorsi during the test with changes in the weight carried, the only significant change in the EMG was the difference between weights of erector spinal muscles, and the muscle activity of erector spinal muscles actually decreased as weight increased, not increased.

Hell *et al*., also suggest that backpack weight also causes some changes in muscle activity. Cook conducted an EMG study of lumbar paraverteverteal muscles in 24 healthy subjects while carrying loads and also found that lumbar paraverteverteal EMG activity was slightly reduced when carrying loads in a backpack position or on the hand on the same side, compared to walking without external loads. And a significant increase in contralateral EMG activity in the load - bearing hand. Devroey *et al*., showed similar results with reduced activity of the back muscles and increased activity of the abdominal muscles, indicating a decrease in co-contraction between the abdominal and back muscles, which is most likely one of the causes of back pain.

Khabbaz *et al*.,'s study found that when carrying a backpack of different weights, the muscle activity of the vastus medialis and biceps femoris did not change significantly, while the activity of the rectus abdominis gradually increased with the increase of the weight of the backpack, and the muscle activity of the rectus abdominis on both sides was not balanced, which was also consistent with Motman's study results. The most significant muscle and posture changes occur when the weight of the backpack is 20% of body weight, so the weight of the backpack should be kept below 20% of body weight as much as possible. The same goes for studies on the effect of backpack weight on muscle activity. Simmon *et al*., 's study showed that a lightweight backpack weighing about 3% of body weight reduced peak lumbosacral pressure during walking compared to a backpack free state. The most critical changes in trunk muscle activation and lumbosacral joint load occur when the weight of the backpack is 10% of body weight, so the weight of the backpack should be kept below 10%. This is also confirmed by the study of Rodrigues *et al*., The weight of the backpack has a significant effect on the stability and muscle activity of the trunk during walking, and also has some effect on gait, with the exception of a backpack of 10% body weight, so it is recommended that the safe weight of a backpack for adolescents and young adults is 10% body weight.

According to the results of various studies, when backpack causes changes in neck muscle activity, the Angle of head tilt also changes accordingly. Park *et al*.,'s study explored the effects of backpack weight on cranial vertebral Angle and neck muscle activity of college students. The changes of cranial vertebral Angle during backpack were significantly reduced in the order of 0%, 10% and 15%, compared with carrying 10% of body weight. When carrying 15% of body weight, the EMG activity of neck muscles increased significantly. Therefore, Park *et al*., suggest that cranial vertebrae Angle decreases and neck muscle activity increases as backpack weight increases, including the superior trapezius and sternocleidomastoid muscles. They also recommended that no more than 15% of the weight of a backpack be carried.

2.5 Influence of backpack walking time on muscle activity

Some scholars have also studied the correlation between backpack walking time and trunk muscle activity. Hong *et al*., asked 15 children to carry bags of different weights for 20 minutes, and recorded the EMG activities of the upper trapezius muscle, lower trapezius muscle and rectus abdominis muscle at several time points (0, 5, 10, 15 and 20 minutes). The results showed that when the backpack walking time reached 15 minutes, the muscle activity of trapezius muscle was significantly enhanced when carrying 15% of body weight; when carrying 20% of body weight, the muscle activity of the lower trapezius muscle increased from 5 minutes, the muscle fatigue of the upper trapezius muscle began at 15 minutes, and no increase in muscle activity was found within 20 minutes. But muscle fatigue was observed after 10 minutes. But unlike some previous studies, Hong et al. found no increased muscle activity or muscle fatigue in the rectus abdominis muscle, which is clearly at odds with the Devroey and Cook *et al*., findings. But it is equally recommended that children's backpack load should be limited to no more than 15% of their body weight, and walking for no more than 20 minutes, to avoid muscle fatigue.

3. THE CONCLUSION

The type and way of backpack, the weight of backpack, the design of backpack strap, the position of backpack and the time of backpack all have different degrees of influence on the muscle activity of teenagers. Single side backpack, double side backpack, cross body backpack will cause significant changes in muscle activity, and both sides of the muscle activity are unbalanced; The heavier the weight of the backpack, the more obvious the changes in muscle activity caused by it, and the more likely to lead to spinal health problems; Backpack strap length did not affect muscle activity, but narrow strap spacing caused more significant muscle activity and increased neck muscle discomfort than wide strap spacing. The high position of the backpack caused more significant muscle activity than the low position; The longer the pack, the stronger the muscle activity. At present, the improvement idea of the backpack is mainly to disperse the concentrated weight of the back or adjust the flexibility of the backpack.

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