

The Physical Ergonomics Body Posture In wearing bags; A Review Article

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Abstract:

This study aims to highlight the key physical ergonomic requirements when designing bags as well as the anatomical nature of the body postures where bags are worn. It also seeks to provide feedback for institutions interested in ergonomic design. The study utilized the descriptive analytical approach due to its relevance to achieving the objectives of the study and verifying its hypotheses. The study offers a description of the natural anatomical nature of the body postures where bags are worn. Both researchers have utilized the inductive method through reviewing past Arab and foreign literature as well as the literature available on the international information network. The study concluded that physical ergonomic criteria must be considered when designing bags. The study also offers an overview of latest trends in the ergonomic domain to enhance human performance and product development. As such, it can be seen as a useful guide for comprehending the ergonomic principles of smart design. The two researchers recommended that it be mandatory to adopt the ergonomic aspects in fashion design and its accessories. It is also suggested to conduct extra research on the impacts of ergonomic considerations on fashion design and its accessories.

Keywords:

physical ergonomics, anatomical nature of the body, bags.

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1- Introduction:

Designing clothing accessories is nothing more than an artistic endeavor that incorporates innovative components in this field to meet human demands, which may be which may be aesthetic, functional, or economic. To imagine or visualize an inventive shape that is subject to the process of organizing its components in a manner that creates a visual format in light of the commonly acknowledged standards in composing a piece of artwork requires a certain set of mental talents (El-Gohari et al., 2014). Fashion accessories (bags) constitute one of the areas of design that have a special nature. To attain success in the design process is based on the designer's ability to understand the nature of the field of accessories, and the associated foundations, including the ergonomic values of bags, associated with the composition of the design (Shaker and Al Maddah, 2017).

The bag is used to carry personal belongings during travel. Over time, we have become in dire need of more bags as it is one of the indispensable necessities for carrying various things, including personal belongings, work requirements or even trips (Madi and Shalaby, 2018). In this regard, this study is the first to examine the topic of ergonomic bag design.

Although ergonomics is usually perceived primarily as related to the physical conditions of the workplace, it really has a much broader scope. Therefore, the two researchers will highlight

ergonomic design, which emphasizes satisfying human needs at all levels of society, with regard to the application of ergonomic considerations to the product design process (Sadeghi, 2020), where ergonomics is integrated with multiple disciplines with the purpose of enhancing objects and processes of human use (Teyeme, 2021).

According to Harby (2020), the functional performance of the bags entails its suitability in terms of design to conduct its functions efficiently and easily, by identifying the required functional performance characteristics. Functional compatibility represents one of the key factors that lead to the success of the design of fashion accessories (bags) and their suitability for the purpose for which they are designed. This is done by taking into account the physical strength of the user in proportion to the average levels of weight, shape, size, and distribution of loads, taking into account the body position according to performance requirements, the user's quality and abilities, as well as aligning with the social and cultural aspect of the user and their respective age stages (Al-Hebairi, 2016).

Therefore, the two researchers found it necessary to study the anatomical nature of the body postures where the bags are worn. When the product is designed for human use, the requirements of these users must be considered. The specifications should specify the principles underlying the design of the product, as ergonomic problems arise in case of having a mismatch between the requirements that

the products must meet within the environment and the expectations of users for performing these tasks. Accordingly, things get more complex when having discrepancies between users in terms of individual differences (Galil, 2017). Therefore, both researchers have perceived the significance of studying the physical ergonomics of carrying bags. So, the research problem can be formulated in the following questions:

- 1- What are the measurements and anatomical characteristics of the body postures where bags are worn by diverse groups?
- 2- What are the physical ergonomic considerations in enhancing and upgrading human performance?
- 3- What is the physical appropriateness for the bag design to avoid ergonomic damage to common wearing areas?

2- Objectives of the Study:

- 1- Identifying the key physical ergonomic requirements when designing bags.
- 2- Highlighting the anatomical nature of the body postures where the bags are worn in terms of movement and physical ability.

Significance of the Study:

- 1- The study sheds light on the significance of the contributions of the physical ergonomics to the fashion accessories industry, especially bags.
- 2- The study contributes to setting ergonomic considerations, which in turn assist with achieving the best functional performance of the products.

3- Study Approach:

The study adopted the descriptive approach and the analytical approach for their appropriateness to realize the study's objectives, and to verify its hypotheses. The study describes the natural anatomical places of wearing bags. Both researchers have utilized the inductive method through reviewing past Arab and foreign literature as well as the literature available on the international information network.

4- Terminology:

1-4-1 Physical ergonomics: It is a branch of ergonomics that deals with the human reaction to physical loads, through studying the anatomy and positions of the body and its relationship to product design (Abdul Latif and Mansour, 2018).

1-4-2 Bags: They serve like containers for people's things and necessities; they were originally woven by hand with linen threads, and then they were made of thick paper (Darwish, 2021). The two researchers define it as one of the key separate clothing accessories, which have different types according to the purpose of carrying and acquisition, and according to how they are worn, as there are bags that are carried in the hand, others in

the arm, and backpacks or shoulder bags.

5- Theoretical Framework:

5-1 The Origin of Bags:

A bag is where we put things such as goods and provisions, it takes the form of a container used to put things in it; it has assorted colors, shapes, and sizes as it can be held in hand or put on the shoulder (Madi and Shalaby, 2018). The internal components, such as pockets and slots to divide and organize the bag to make it easy to get what the user needs, differs as well (Harby, 2018). It was originally woven by hand with linen threads, then thick paper (Darwish, 2021). It is an integral part of elegance, fashion, and a symbol of social and economic status (Noureddine and Muhammad, 2018). Also, it expresses the wearer's personality and body measurements (Al-Adawi, 2018).

It is essential to study the origins of bags as traditional shapes can inspire modern design visions. The bag industry is one of the advanced vital industries that rise to global markets (Harby, 2020). In the past, bags were made of animal skins. In later times, leather was also used to make accessories that would help carry things from one place to another (Sachidhanandham, 2018). Men were the first to use bags to hold their essentials, papers and money when traveling, followed by women at a later time (Madi and Shalabi, 2018). In the sixteenth and seventeenth centuries, bags were hung from a person's belt (Samaan et al., 2019).



Figure (1-1) Assyrian of a handbag 800-850 B.C.; <https://air-fashion.com>, 2020



Figure (1-2): the oldest preserved bag in history <https://air-fashion.com>, 2020

In 1908, Ole F. Bergans invented the metal frame rucksack shown in Figure No. (2-32). Bergans believed that the rucksack should be designed according to the person's shape and height and should resemble the shape of the body. So, using mild tubular steel, he bent a simple structure to follow the shape of the human back. The structure also made the bag more comfortable to carry because it prevents any hard objects from reaching the user's back <https://carryology.com>, 2020)



Figure (1-3) Bergan Rucksack
(<https://carryology.com>, 2020)

In 1952, Dick and Nena Kelty began handcrafting external-frame backpacks (Kelty Backpacks) as they formed and welded the first packs by using aircraft aluminum. Then, the TUMPLINE system was introduced. It is used to carry the object by placing the strap over the top of the head. This utilizes the spine rather than the shoulders as standard backpack straps do. Tumplines are not intended to be worn over the forehead, but over the top of the head just back from the hairline, pulling straight down in alignment with the spine. It originally appeared in Chouinard's 1980 equipment catalog (Phelan, 2000) as shown in Figure (1-5).



Figure (1-4): shows how the load is transferred over the top of the head.



Figure (1-5): A TUMPLINE;
(<https://patagonia.com>, 2021)

5-2 Types of Bags:

Bags constitute one of the oldest art forms made to hold special tools inside. People use several types of bags in their daily life. Bag preferences vary according to the age. Children use backpacks, while cross bags and handbags are mostly used by adults (Kim et al, 2021). Bags are carried in diverse ways with different postures (Madi et al., 2017). Kim et al (2021) quantitatively analyzed the morphological gait parameters and displacement of the center of pressure (COP) of the human body during walking before and after carrying a cross bag. Other factors that influence musculoskeletal risks include the way of wearing, the length of the shoulder strap, the weight of the bag, and how long the consumer spends wearing it (Ramadan & Al-Tayyar, 2020).

According to a study by Chen et al (2021) on the effect of three methods of carrying bags on body posture (backpack, side backpack, and cross-body carrying) as shown in Figure (1-6), the side backpacking method should be avoided because of relatively high lateral shoulder tilt (LST) and trunk angle (TA) values, as well as right trapezius (RTZ) activation, this unbalanced load may cause an uneven shoulder posture therefore may result in spinal scoliosis when compared with the other two carrying methods.



Figure (1-6): The three ways of carrying (Chen et al, 2021)

5.3 Ergonomic Considerations:

The interest in improving human performance, upgrading it, reducing the incidence of injuries, and achieving satisfactory performance, may depend on the correct application of the considerations and aspects of ergonomics when designing. This involves applying theories, principles, data, and methods in design for the purpose of improving human life (Haraz et al., 2017). In the process, the interdisciplinary characteristic of ergonomics is perceived as a factor that helps in the mediation between the body and the clothing, once this science may offer constructive tools that may be able to provide safety, comfort, and health to users. (Das Neves, et al, 2015). Therefore, there are ergonomic design considerations that must be considered for the success of the design process, which are:

5-3-1 Anthropometric Considerations for Design:

The word "anthropometric" means the measurement of one of the parts of the human body or the whole body. It is a word derived from two Greek words: (Anthropo) which means man and (Metry) which means measurement. It is a branch of anthropology (Khalil et al., 2019). In the context of fashion, to develop a suitable design it is necessary to know the human anatomy as well as the functions of the body that must be considered and exploited in order to obtain consistent data for the development of suitable products. (Das Neves et al, 2015).

Anthropometric measurements are defined as the study of the measurements of the human body, and it includes the measurement of height, weight, volume, and dimensions of various parts of the body. It also refers to the rest of the physical characteristics (Khalil et al., 2019).

In the same vein, the physical and structural characteristics of the clothing that configure this fashion product stimulate the positive evaluation of the user regarding a certain product, as the use of anthropometric data when designing will improve the user experience (Das Neves et al, 2015).

For instance, moving some weight to the front of the body can help deal with the weight of a heavy backpack (Kulshrestha and D, 2017), as shown in Figure 2-5. The anthropometrics and social characteristics of each target group must always be considered within the creative process.



Figure 1-8 shows the distribution of bag carrying (Kulshrestha and D, 2017)

5-3-2 Psychological considerations:

According to (Batra and Seifert, 2015), the psychology of design is the study of the impact of design on consumers, so that it creates a sense of emotional and sensory appeal that results in attracting the consumer. The product design must consider the psychological aspects of the user and the functions of its members and dimensions, as ergonomics is concerned with the compatibility and appropriateness between the human being and other components of the systems and environmental stimuli that he deals and interacts with in his daily life system.

The consumers are searching increasingly for fashion products that present unique physical qualities such as usability and meet their needs and expectations. From this perspective, this impacts the design stages as well as the manufacturing process. For this, the understanding of specific segments of consumer and users emerges as a competitive strategy favorable to the fashion products which are adequate and satisfactory to specific needs and desires (Das Neves et al, 2015). Several researchers have extensively studied the physiological, biomechanical, and psychological effects of several types of bags. Some past literature has also provided a comparison of some diverse types of bags.

5-3-3 Material and Technical:

The product must be based on the use of materials that are characterized by durability and reliability to fulfill the conditions of use, considering the homogeneity of the color, lines, and material of the bag with the clothing to create a kind of unity and compatibility (Madi et al., 2017). Techniques for each material vary. When fabric was used to make the bag, it was used with beads or threads. As for leather, its techniques varied as drilling or burning were adopted. Metals, also, were found to enjoy a variety of metal formation techniques, such as inlaying with stones, casting, repoussé, and slitting (Samaan et al, 2020).

Ibrahim and Abdel- Khaleq's study (2021) recommended diversifying the use of fashionable materials and techniques. The evolution of clothing and its accessories depends on the material revolution and the industrial revolution. The

development of materials brings about new functions to clothing and new opportunities for human society. One solution is the integration of both wearable computing and the Internet of Things (IoT) as mentioned by (Wang & Wang, 2021). The bags differ according to the material they are made of. In this regard, it should be mentioned that bags are made of multiple materials, including natural or artificial leather or plastic (Darwish, 2021). Cloth of all kinds is also used (Madi and Shalabi, 2018), where ropes, wood, beads, straw and crochet, or macramé and knitting can be utilized (Sarukh and Al-Sarhan, 2018).

The type of raw material comes first before shape, color, and function. However, the new materialism goes much deeper than that. Materialism refers not only to materials such as fabrics or clothing, but also to the wearer's body (Smelik, 2018).

5.4 Physical Ergonomics:

Several domains fall under the umbrella of ergonomics. Researchers have differed in their classification methods. Following a review of past literature, researchers have classified them into cognitive ergonomics, organizational ergonomics, environmental ergonomics, emotional ergonomics, and physical ergonomics. Full mastery of physical ergonomics increases safety, improves health, promotes performance efficiency, and reduces the cost of products and consequently their selling price to the consumer (Mustafa, 2010).

It includes the study of the consumer through an understanding of their physical characteristics, capabilities, limitations, and motives, as well as an understanding of functions, tasks, and safety procedures (Dawood, 2021). One of the objectives of ergonomics is to adapt everything that surrounds the human being to his body parameters and ability (Al-Abadi, 2014).

Bags are closely related to walking. Gait is the most basic way and the most generic form to move the human body and normal walking is characterized by symmetrical movement around both limbs and L5 / S1 joints, the process using musculoskeletal and nervous systems collectively, repetitive, and continuous movement that requires balance and high coordination of the body and depicts walking actually. In addition, gait may cause the body to deform asymmetrically depending on the type of bag or how to carry (Kim et al, 2021).

Mosaad & Abdel-Aziem (2018) reported that the shoulders and back are the fundamental areas that cause pain when the back is overloaded. The researchers identified the communal areas of wearing a bag on the body (shoulder, neck, pelvis, back, chest), according to the design needs of its various branches in general, and the design of bags in particular:

5-4-1 Shoulder Area:

Previous studies have suggested that wearing a backpack on both shoulders is the safest method, emphasizing that the backpack's straps should be padded and anthropometrically adjustable. A standard backpack should have chest and waist strap to reduce the force of centre of gravity acting on shoulders (Khan et al, 2021). The top of the backpack should not be higher than the shoulders and the bottom should not be lower than the top of the hip bone (Alami et al, 2020).

It should be noted that the shoulder on which the bag is carried should be used interchangeably to minimize changes. It is therefore essential to raise awareness of the risks posed by the misuse of a shoulder bag (Matos et al, 2020). In general, when people carry cross-body bags, they maintain balance by unconsciously changing the alignment of the shoulders and spine (Kim et al, 2021). A study by Lashway et al. (2017) revealed that ergonomically uncomfortable backpacks tend to cause spinal and orthopedic-based dysfunction.

According to a study by Matos et al (2020) - which focused on females- revealed that carrying shoulder bags, especially on the right side, weighing more than 5% of a woman's body weight, caused changes in the basic components of walking, thus affecting the gait cycle, and increasing the load on the front of the part of the foot. It is crucial to stress that it is impossible to analyze the use of the bag without considering the external factors, which directly or indirectly impact the weight of the bag, such as physical activity and childbearing. It is necessary to be careful when selecting the type of bag because the wrong type contributes to back and shoulder pain (Alami et al, 2020).

5-4-2 Neck Area:

Ergonomics is concerned with studying the requirements for the performance of the individual's body for various tasks, and its movement during its performance in proportion to the conditions of the body, as the individual's performance of tasks in a manner that is appropriate and consistent with his abilities helps him to do them happily and with satisfaction and without making a great effort; and this can be a treatment for his problems that can affect his productivity (Haraz et al., 2017). The neck is characterized by its ability to perform movements between flexion and extension, lateral flexion and extension, and rotation. Restricting this movement disrupts its function and leads to a lack of comfort and safety during use (Onsi et al, 2019). Therefore, the design of bags must consider the appropriate position for the movement of the neck.



Figure 1-10 Effect of carrying the bag on neck, shoulder, (<https://learnmuscles.com>, 2017)

5-4-3 Pelvic area:

The pelvic area forms the lower part of the torso, between the abdomen and thighs, where the pelvis tilts forward, backwards, leftwards, and rightwards and can rotate and play a role in supporting weight (Kim et al, 2021).

When walking, the hips rotate in a pendulum-like motion. As the weight of the bag fluctuates with each step, it can lead at best to general discomfort and at worst to a complete loss of balance, especially when jumping, moving on one side, or taking big, irregular strides. Active suspension systems are one way the designers use to solve the stiffness/weight change problem by adding a degree of flexibility and movement to the frame. The challenge is to find the delicate balance between increased mobility and structural stability (<https://carryology.com>, 2020).

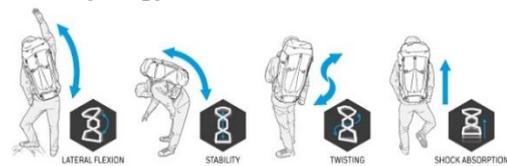


Figure 1-11: Torso Physiology (<https://samsonite.fr>, 2018)

Backpacks are often designed with hip straps to reduce the load on the shoulders, which can reduce injury to the back as part of the load goes to the pelvis. The lower extremities have similar rates of injury to the back and spine. However, the hip suffers the least number of injuries to the lower part and may be more resistant to loads than other joints (Sturdy et al, 2021). Several experts believe that the bag should weigh less than 10% of the body mass, while other institutions and other researchers believe that the ratio should be from 10% to 15% of the body mass and that any increase can lead to a change in heart beats (Abu Hawass and Al-Salih, 2020). When wearing a backpack, the center of gravity shifts back. To compensate for the shift, the body leans forward causing muscle distress. This shift in position is likely to cause tissue damage and has been associated with spinal pain (Khan et al, 2021).

5-4-4 Back Area:

Backpacks used in everyday life for the hands free carrying. Over time, however, walking or running with a heavy sack can cause back and neck pain (Yang et al, 2021) and also this could impact

shoulder, spine, and extremities (Lee et al, 2021). A backpack is a container placed on an individuals' back, which is protected by two straps extending vertically over the shoulder (Layuk et al, 2020) and it is a practical and versatile form for carry different loads (Daffin et al, 2020).

Improving balance in movement is a major factor in the design of any product. Based on a study by Mosaad & Abdel-Aziem (2018), carrying a double-sided bag restores the balance of the body and head to a state similar to that of non-carrying. When the bag is carried over one shoulder, to achieve a stable position, there is a lateral shift of the torso. This temporary change in spinal curvature is called functional scoliosis (Khan et al, 2021) as shown in Figure (1-12).

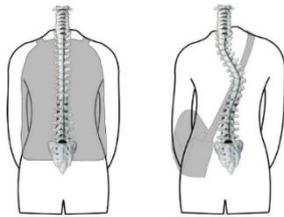


Figure 1-12: The impact of the side bag on the spine (https://ro.outletshop.ru , 2021)

Daffin et al (2020) confirmed that backpack users need to consider not only the total weight of their backpack, but also how individual items are placed inside the backpack pockets. Heavy items should be positioned as close as possible to the center of mass of the backpack carrier as this will reduce their relative contribution to the total external torque generated by the backpack. Alternatively, double-

sided packs of assorted designs can be a viable option to redistribute the load depending on its size and shape.

Golriz et al (2018) showed that carrying during carrying a 20% body weight loaded backpack leads to a significant increase in muscle fatigue, blood pressure and forward trunk and head angle. In the same vein, Abdon et al (2018) pointed out that women should not carry bags weighing more than 4% of their body weight. The increased mass of the backpack also makes starting the movement more difficult and requires greater control of movement around the axes of rotation, which in turn may lead to falls and injuries (Heller, 2009). Studies have proven that carrying a bag of inappropriate weight may be one of the reasons for the forward bending of the torso and neck (Abu Hawass and Al-Saleh, 2020).

Ramadan& Al-Tayyar (2020) developed an ergonomically advanced backpack, whose design was based on ergonomic features and criteria, such as bag comfort scale and the percent of maximum voluntary contraction (%MVC) of six muscles (right and left of erector spine, right and left of external abdominal oblique muscle, and right and left of trapezius) with astonishing performance at levels of 15% and 20% of body weight. It provided significant results with regard to enhancing the muscles for carrying 10% of the body weight through using a backpack of this dimension.

Table 1-1: Burden of bag weights on the spine (Hansraj et al, 2018)

Weight		Normal posture of the spine			20 degrees forward		
		Felt stress MPa	Added reaction force		Felt stress MPa MPa	Added reaction force	
lb.	kg		(N)	(lbf)		(N)	(lbf)
1	0.45	0.0242	32.28	7.23	0.466	51.73	11.63
25	11.34	0.605	8.4.40	180.83	161	1293.3	290.75
50	68.22	1.21	1608.8	361.664	32.2	2586.6	581.5
75	34.02	1.79	2380.96	535.28	47.7	2586.6	860.62
100	45.36	2.42	3217.6	723.36	64.4	5173.5	1163

According to Table No (1-1) it is clear that for all the weights that were examined, the axial compressive force of the neutral spine was 7.2 times the weight of the backpack. For the 20° forward flexion condition, the axial compressive force was 11.6 times the weight of the backpack. A lot of past literature dealing with the impact of wearing bags on human gait focused on children and school bags in particular. However, many adults carry a heavy external load such as a backpack.

Reported bag-wearing problems also involve changes in spinal curvature and forward tilt of the head and trunk (Ramadan & Al-Tayyar, 2020).

Walking is the most complex task performed by humans and several segments of the body perform many complex movements and interactions in order to adapt and ensure proper posture and thus enable normal posture using various kinds of shoes and bags, weight gain and load (Matos et al, 2020).

One of the traditional theories states that carrying a heavy bag on one side for a long time or habitually, or if the weight, shape, method of carrying and the location of the bag are incorrect as in Figure (1-14), this may lead to abnormal pressure on the body, leading to problems with the musculoskeletal system, such as scoliosis. Pain and physiological impacts can also cause negative changes in

dynamic balance, leading to the selection of an ineffective walking strategy that requires high coordination (Kim et al, 2021). Yet, Chen et al (2021) hold an unfamiliar perspective as they assert that the cross-body method of carrying the bag is popular due to the obvious comfort it provides.



Figure 1-14: The impact of carrying cross body bags on the body

(<https://seasidewellnesscenter.com> , 2019)

The left and right asymmetry of the trapezius muscle was clearly observed while carrying cross-bags on the right side of the body, similarly, the asymmetry of abdominal muscle was actively observed (Kim et al, 2021).

5-4-5 Chest Area:

The abdominal muscles are more active during carrying, standing, and walking (Sturdy et al, 2021). The double-sided bag affects the head posture and improves postural stability compared to traditional backpacks. Yet, it was found that the use of a front pack caused less change in the center of gravity (COG) and lower trunk slope, but it is in turn associated with an increased incidence of thoracic kyphosis (In & Jang, 2019).



Figure 1-17 Balancing the load on the chest with the back (<https://enstocks1d.top> , 2018)

5-4-6 Hand:

Handbags are one of the key accessories that are always characterized by diversity and innovation in their designs according to the conditions of each society and the prevailing fashion. It involves adding a piece that accompanies the main attire and leads to elegance, even if it is in itself secondary (Noureddine and Muhammad, 2018). The standard dimensions of the movement of the arm and the human hand must be known when designing. The person's ability to carry the bag is represented by a pull force at an angle of 90° for the right arm = 17 kg, and the pull force for the left arm at an angle of 90° is 14.5 kg. It should be also noted that the fingers of the hand have a comfortable carrying capacity of 3-5 kg and they cannot carry more than that so as not to stress the joints and muscles (Al-Abadi, 2014).

The processed data obtained from an experiment conducted by (Atreya et al, 2010) revealed that people feel comfortable when wearing an arm bag, as this contributes to improving the load distribution as shown in Figure (1-20). Carrying a traditional backpack increases the anterior flexion of the torso (In& Jang, 2019).



Figure 1-20 the method of distributing the load on the arm (Atreya et al, 2010)

6- Results and Discussion:

First: ergonomics integrates with multiple disciplines, to improve the design and use of products.

Second: The weight of the bag and the way it is carried are amongst the factors that impact our bodies, and the added weight of the bag acts as an external load and affects many features of the body.

Third: The ergonomic backpack should include wide, lightweight, adjustable shoulder straps and well-padded waist straps, and should have many internal pockets to put different things.

Fourth: The heavy weight bag swaying with each step can lead to noticeable discomfort in the pelvic area.

Fifth: It is likely that some fashion trends in the designs of bags will negatively impact the health of the one who carries it.

7- Recommendations:

The researchers have made the following recommendations:

- 1- Carrying the backpack on both sides to maintain the equilibrium of the body during movement.
- 2- Keeping the weight of the bag less than 10% of the body weight.
- 3- Getting rid of the extra personal belongings inside the bag to relieve pressure on the spine.

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