A Project entitled

The effect of a backpack with Anti-gravity System (AGS) on easing the shoulders' pressure

Submitted by

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Declaration

I, Chan Hok Leung declare that this research report represents my own work under the supervision of Prof. Chow Hung Kay, Daniel, and that it has not been submitted previously for examination to any tertiary institution.

Signed _____

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Content

1. Abstract

Purposes: To evaluate the effect of a backpack with Anti-Gravity System (AGS) on decreasing the shoulder pressure. Methodology: 15 males subjects aged 20 to 31, carried three types of backpacks (control, old-AGS version, new AGS-version) with 6.9kg loads. Interface force sensor was placed over the left shoulder. The interface shoulder pressures were measured when the subjects were completing the tests on the treadmill, including stand still for 30s, walking at 3.5mph for 90s and remain in place for 30s. The vertexes of measured interface pressure in gait cycle were captured for data analysis. Each type of backpack was tested for twice. Result: No significant difference was observed between AGS-backpacks and non-AGS backpack on the shoulder measured pressure. In the meantime, no significant result showed the differences between the vertexes of measured pressure in gait cycles among three backpacks. Conclusion: There is no evidence to show the effectiveness of AGS backpack on decreasing the shoulder pressure. However, further study from different aspects to find out the effectiveness of AGS-backpack were needed.

Keywords: Anti-Gravity System, backpack, shoulder pressure, elastic shoulder straps

2. Introduction

Backpack is a necessary item for us, it is widely used as a daily carriage, especially for students. Students carry books, laptop, and other belongings daily, it could not be overlooked if there are any health problem caused. Much research reported that the weight limit of the backpack should not exceed 10-15% of body weight. (Ismaila, S. O. 2018, Brackley, H. M., & Stevenson, J. M. 2004.) Carrying a heavy backpack daily is not suggested and the weight of backpack affected posture, gait and caused back pain. (Brackley, H. M., & Stevenson, J. M. 2004)

The aim of this study is to evaluate the effectiveness of AGS-backpack on relieving the interface shoulder pressure. Anti-gravity System (AGS) is a registered technology developed by FX Creations Enterprises Limited. It conducts elastic shoulder straps, and it creates a bouncing motion when the user is walking. It aims at easing user's constant loads of the backpack, like a suspension system behind. FX creation is a local company, aiming to enable daily carries, for examples backpack and crossbody bag, providing comfort and different experiences on daily carries. AGS backpacks are the most famous technology and popular products in their company.

Therefore, this study is first going to evaluate the effect of a backpack with Anti-Gravity System on decreasing the shoulder pressure by comparing to ordinary backpack. During this study, direct measurement of backpack-skin interface pressure was adapted in the study for measuring external forces applied on the shoulder by the backpack. However, no significant results were found and furthermore studies from different aspects to find out the effect of AGS-backpack is needed.

3. Literature Review

The load of backpack is the most important factor when carrying a backpack. The present findings already reported the heavy loads of backpack increase the shoulder-interface pressure and physiologically pain. (Shamsoddini, A. R., Hollisaz, M. T., & Hafezi, R., 2010). Despite AGS-backpack can relieve the shoulder pressure or not, the weight you carried is more important than what types of backpacks you put on. However, there is no option in real-life situation sometimes, for examples students need to put on the laptops, books, stationery in their backpack. also, that is the reason why AGS-backpack would like to provide a better experience on carrying a backpack. If the weights of backpacks or the interface pressure on the body are decreased, the probability of health issues happened would be decreased. (Sheir-Neiss, G. I., Kruse, R. W., Rahman, T., Jacobson, L. P., & Pelli, J. A., 2003).

Research reported that the backpack weight had a strong relation to the shoulder interface pressure by using the biomechanical model. Also, it suggested that we should carry the backpack with the least weight possible. (Bryant and Reid, 1996) Determining shoulder pressure is one of the approaches to evaluate the influences on overweight of backpack to musculoskeletal pain or discomfort. When carrying a backpack, the shoulder is the majority part to bear the weight of a backpack. interface shoulder pressure was selected by much research to evaluate the relation between the loads of backpack and different situation design, for examples the influences on single or multiple layers of clothing to shoulder pressure. (Jones, G. R., & Hooper, R. H. 2005). Therefore, the interface shoulder pressure measurement was useful to compare different backpacks.

Thus, different products for carrying loads were launched to the market. For examples, cross body bag and tote bag. Different carries are designed instead of 2-strap backpack. However, the research reported that side backpack carrying should be avoid because it may cause an uneven shoulder posture and result in extra body strain. (Chen, Y. L., Nguyen, H. T., & Chen, Y., 2021). Therefore, 2-strap backpack are suggested for carrying loads in sake of the body posture and reduce extra energy

expenditures.

Research reported that the importance on hip-belt, the position of weight, shoulder straps. (Bryant and Reid, 1996., Abdelraouf, O. R., Hamada, H. A., Selim, A., Shendy, W., & Zakaria, H., 2016.) when we are carrying a backpack with heavy items, there is a necessary to ease the burden to our body. The accessories and the position of loads are the factors to ease the pressure and provide a comfort experience when carrying weights.

SPI backpacks are popular local brand of backpack. SPI backpacks claimed that their backpack provided protection of spine for the user. Also, it was awarded as Consumer Product Design Award in Hong Kong Awards for Industry by federation of Hong Kong Industries (FHKI) in 1999. (Hong Kong Awards for industry, 1999) SPI backpacks were selected by many students in Hong Kong. Thus, it triggered the concerns on the health issues when carrying a backpack, which is the reason many parents are selecting SPI backpack. However, there are not related research study on the effectiveness of SPI backpack. Thus, there is no idea how SPI backpack provides the protection of spine for children.

4. Methodology

4.1 Subject

To measure the shoulder pressure when carrying the AGS-backpacks, 15 male adults were recruited and all of them gave signed informed consent and PAR-Q form to participate in the study. Their mean (Standard Deviation) of age, height and weight were 23 (2.78), 174.13cm (6.0) and 68.81kg (10.4), respectively.

4.2 Study Design

The reason selecting male adults for the study is because the accessibility of the study. The group of participants are the students of The Education University of Hong Kong, which was easier to contact, and they were more likely to attend the test in campus. Apart from that, the consistency was the reason they were selected. It was easier for the study design, for examples, the fixed loads of 10% body weight, to eliminate the confounding factors.

Three types of backpacks were conducted in the study, including control, old and new version of AGS-backpack. (See fig. 1 to 6) All backpacks were provided by FX Creations International Ltd.

The difference between old and new version of AGS-backpacks are the materials of the spring behind the backpack. A stick was used in the spring for old version AGS-backpack and double steel wires were used for new version AGS-backpack. New version AGS-backpack are more likely to provide a quiet and less friction spring behind comparing to the old version AGS-backpack.



(Fig.1,2 Control backpack).



(Fig.3,4 Old-AGS backpack).



(Fig.5,6 New-AGS backpack)

The original weight of control and AGS-backpacks are 0.45kg and 0.65kg. The testing weight of backpack was fixed at 6.9kg, which is around 10% weight of an adult male, which is the suggested percentages of carrying a backpack. (Ismaila, S. O. 2018, Brackley, H. M., & Stevenson, J. M. 2004.) The testing weight is fixed by inputting weight plates which are put closest to the subject's back

because the location of the heavy item may affect the measurement. (Mackie, H. W., Stevenson, J. M., Reid, S. A., & Legg, S. J., 2005.)

4.3 Sensor

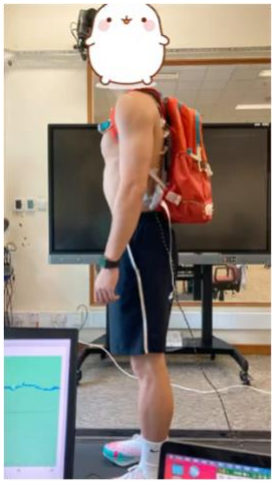
In order to measure the shoulder pressure, an 8mm miniature force sensor by SingleTact Brand was adapted. The sensor was 8mm diameter, it is only 0.30mm thick and it weights 0.23g. It can detect and measure how much force were being applied to the sensor. The data were acquired and recorded using PPS Single Tact Demo version 2.0.51.0. Also, research shown that Single Tact sensor are more accurate than commonly used force sensor resistors (FSRs). (Schoepp, K. R., Dawson, M. R., Schofield, J. S., Carey, J. P., & Hebert, J. S., 2018)

The sensor was located under the left shoulder strap at the subject's shoulder, also fixed by 3M™ Blenderm Surgical Tape, which is waterproof and good at fixation. It ensured the location of the sensor, to avoid any displacement during the test.

4.4 Procedures

Before the test get start, the subjects were required to take off their shirt to avoid any distraction. There were 3 stages in the study, including stand, walk and stand. At first, participants stood still for 30 seconds, looking directly ahead, a sightly move will distract the data collection. After that, participants walked at 3.5mph for 90 seconds on the treadmill and stood still for 30 seconds again. The measurement of interface shoulder pressure got started in the beginning (using 8mm miniature force sensor) at the left shoulder interface.

Each backpack was tested for twice. After two times testing, participants stopped and changed the backpack. The sensor placed at the left shoulder and the location was marked by tapes. When the backpack was changed, the shoulder straps were repositioned, the sensor was placed at similar position under the shoulder straps.



(Fig.4 The participant stood still in the resting time during the experiment)

5. Statistical analysis

After data collection from 15 subjects, there are 3 steps before data analysis. First, 3rd order Low pass Butterworth filter was adapted for filtering data. It was filtering with no time shift and cut off frequency at 6Hz. it refined data set, to exclude repetitive data and irreverent data in the data set.

Second, data drift was offset in excel by linear drifting. The Single Tact sensor may appear 2% drift in 1min, 4% in 10min at 50% FSR load. Data drift caused accuracy of studies degraded and unclear. There are obvious data drifts from the data in the beginning and in the end of test. Most of the result showed the result in the last 30 seconds were higher than the result in the 30 second, which both were the resting time. Therefore, data set was offseted by linear regression in excel and the new datasets version was conducted which excluded drifting.

After offsetting the data drift, only the data from 30 to 120 seconds were captured, which means the resting time (30 seconds in the beginning and in the end) were excluded. The walking periods were only captured because it clearly showed the oscillation on the pressure measured during the tests. From the results, there were steadily up and down trends in the walking time of all backpacks. The vertexes of interface pressure were outputted to conduct 50 gait cycles. Each gait cycle contained phase 1 to phase 4. The peak (Phase2 & 4) and bottom (Phase1 & 3) of interface pressure measured were captured for the data analysis. There were two tests result for each participant of each backpack as they completed the same tests twice. Therefore, the mean results were calculated by two test results for data analysis.

IBM SPSS Statistics Version 27 software program was used to conduct statistical analysis. The mean scores of P1 to P4 in walking time and the mean scores of the differences between P2 and P1, P4 and P3 were conducted. After that, one-way repeated measure ANOVA was conducted for comparing the differences between three backpacks. The independent variables were three different backpacks (Control, New and Old version). The dependent variables were shoulder pressure (kPa).

6. Data analysis (Result)

There were two parts in the data analysis, including compare (1) P1 to P4 respectively and (2) the differences between P2 and P1, P4 and P3. The values of P1 to P4 showed the peak and the bottom of measured pressure in every gait cycle. On the other hand, P2-P1 and P4-P3 showed the ranges of oscillation between the vertexes in each gait cycle.

Shoulder pressure in P1 to P4

The result showed that there was no significant difference of the interface shoulder pressure between P1 to P4 respectively, the significant values were P>0.05. The means (SD) of three different backpacks in P1 were 7.8 (3.5) kPa for control, 6.8 (1.6) kPa for new-AGS and 7.3 (1.7) kPa for old-AGS. In P2, there were 11.7(4.2) kPa for control, 11.1(3.1) kPa for new-AGS and 11.8(2.7) for kPa old-AGS. In P3, the means (SD) were 7.82(3.47) kPa for control, 6.83(1.73) kPa for new-AGS and 7.38(1.65) kPa. In P4, there were 11.85(4.48) kPa for control, 11.07(2.87) kPa for old-AGS and 11.58(2.62) kPa for new-AGS. The result was also shown in table 1. Comparing to different backpacks, Greenhouse-Geisser was adapted since the assumption of sphericity has been violated. The result showed that there is no significant difference between P1 to P4 respectively, and P-values were >0.05 from P1 to P4 under Greenhouse-Geisser correction. P-values were found, and they were 0.327, 0.64, 0.402, 0.611 in P1 to P4 respectively. (See Table 2) It showed that AGS-backpacks were not different from ordinary backpack on the interface shoulder pressure by comparing the means at different time point. From this point of view, the bouncing motion of AGS-system could not ease the shoulder pressure. The result presented the similar shoulder pressure measured between three backpacks.

Table 1 Mean (SD) from P1 to P4 interface shoulder pressure by carrying different backpacks (kPa)				
	P1	P2	P3	P4
Control	7.86(3.5)	11.68(4.18)	7.82(3.47)	11.85(4.48)
New-AGS	6.75(1.6)	11.15(3.05)	6.83(1.73)	11.07(2.87)
Old-AGS	7.29(1.7)	11.79(2.73)	7.38(1.65)	11.58(2.62)

Table 1. The mean score (Standard Deviation) of interface-shoulder pressure in P1 to P4 by carrying Ordinary, Old, and New-AGS backpack.

Table 2 Tests of Within-Subjects Effects							
		Types III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
P1	Sphericity Assumed	9.133	2	4.566	1.074	.355	.071
	Greenhouse-Geisser	9.133	2	7.794	1.074	.327	.071
P2	Sphericity Assumed	3.564	2	1.782	.328	.723	.023
	Greenhouse-Geisser	3.564	1.395	2.555	.328	.647	.023
P3	Sphericity Assumed	7.240	2	3.620	.805	.457	.054
	Greenhouse-Geisser	7.240	1.179	6.138	.805	.402	.054
P4	Sphericity Assumed	4.650	2	2.325	.396	.677	.028
	Greenhouse-Geisser	4.650	1.441	3.226	.396	.611	.028

Table 2. Tests of within-subject Effects in one-way repeated measured ANOVA, under Greenhouse-Geisser level of significance presets at P<0.05.

The differences between P2 and P1, P4 and P3

The peak and the bottom in a gait cycle (P2-P1 and P4-P3), the differences were calculated. The mean (SD) of P2-P1 were 3.82(1.56) kPa for control, 4.39(2.07) kPa for new-AGS and 4.50(1.95) for old-AGS. The mean (SD) of P4-P3 were 4.03(2.12) kPa for control, 4.23(1.89) kPa for new-AGS and 4.20(1.58) kPa for old-AGS. (See table 3) The value means the difference between the peak and bottom interface pressure on the shoulder in a gait cycle. The greater value was shown, the greater differences between the peak and the bottom was found. Mauchly's Test of Sphericity indicated that the assumption of sphericity had not been violated, so it is used for data analysis. There is no significant difference between three backpacks on their differences of the peak and bottom interface pressure, with the significant value<0.05, P value=0.160 for P2-P1, 0.864 for P4-P3. (See table 4) The result showed no significant relation on their rises of their measured pressure in gait cycles. The result couldn't prove the function of the suspension system behind the AGS-backpack different from the ordinary backpack.

Table 3

Mean (SD) of P2-P1 and P4-P3, the interface pressure measured between the peak and the bottom in the gait cycle (kPa)

	P2-P1	P4-P3
Control	3.82(1.56)	4.03(2.12)
New-AGS	4.39(2.07)	4.23(1.89)
Old-AGS	4.50(1.95)	4.20(1.58)

Table 3. The mean score (standard deviation) of the differences between the vertex in the 50 gait cycles, which are P2 and P1, P4 and P3.

Table 4 (P2-P1 and P4-P3) Tests of Within-Subjects Effects							
		Types III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
P2-P1	Sphericity Assumed	4.013	2	2.006	1.960	.160	.123
P4-P3	Sphericity Assumed	.365	2	.183	.147	.864	.010

Table 4. Tests of within-subject Effects in one-way repeated measured ANOVA, under Sphericity's assumption level of significance presets at $P<0.05$.

Table 5 (Control and New-AGS) Tests of Within-Subjects Effects							
		Types III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
P1	Sphericity Assumed	9.131	1	9.131	1.655	.219	.106
P2	Sphericity Assumed	2.114	1	2.114	.294	.596	.021
P3	Sphericity Assumed	7.211	1	7.211	1.184	.295	.078
P4	Sphericity Assumed	4.501	1	4.501	.634	.439	.043

Table 5. (The comparison between control and new-AGS) Tests of within-subject Effects in one-way repeated measured ANOVA, under Sphericity's assumption level of significance presets at $P<0.05$.

The comparison between Control backpack and New-AGS backpack were conducted in table 5. The result showed that there is no significant difference between the ordinary backpack and New-AGS backpack, the significant levels of comparing P1 to P4 are >0.05. The result showed that even old-AGS was excluded, the difference between new-AGS and control still was not significant.

Table 6

(Control and Old-AGS) Tests of Within-Subjects Effects

		Types III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
P1	Sphericity Assumed	2.395	1	2.395	.368	.544	.026
P2	Sphericity Assumed	3.133	1	3.133	1.690	.215	.021
P3	Sphericity Assumed	1.431	1	1.431	.215	.650	.015
P4	Sphericity Assumed	.527	1	.527	.064	.804	.005

Table 6. (The comparison between control and old-AGS) Tests of within-subject Effects in one-way repeated measured ANOVA, under Sphericity's assumption level of significance presets at P<0.05.

The comparison between control backpack and old-AGS backpack were conducted. (See table 6) The results showed that there is no significant difference between control group and old-AGS group, even compare without new-AGS backpack, significant levels in P1 to P4 were >0.05.

7. Discussion

There is no evidence to reject the null hypothesis, as there is no difference between three backpacks, including control and AGS-backpacks. Under the statistical results, the effectiveness of AGS-backpack was not obvious, including (1) compare the vertexes of interface shoulder pressure of different backpacks and (2) the suspension system for easing the shoulder pressure by comparing to the ordinary backpack. Even though the results were not positive, the effectiveness of AGS-backpack still could not be denied yet. Based on the design and mechanism of AGS-backpack, there are obviously different from the ordinary backpack. The aim of this study is to evaluate the effects of AGS-backpack on easing the shoulder pressure. From the point of view, it is only one of the approaches to evaluate the effectiveness of AGS-backpack, there is necessary that to test the function of AGS-backpack from different aspects. Further studies are needed, to evaluate the AGS-backpack by different design of the test.

The comparison between Control group and AGS-group respectively

The result in table 5 and 6 showed that there were no significant differences between New-AGS backpack and control backpack, Old-AGS backpack and control backpack. The reason why compares AGS-groups and control group respectively were because the similarity of new-AGS group and old-AGS group. it may influence the significant level when comparing to three backpacks. To show the comprehensiveness of the study, the comparison between control and AGS-groups were also conducted. The results showed that the differences between ordinary backpack and AGS-backpack were not significant on interface shoulder measured.

The width of shoulder strap

The width of shoulder strap was a factor affecting the shoulder pressure measured. Research reported that the width of shoulder strap influences the shoulder pressure, 8m shoulder strap showed the least interface shoulder pressure measured by comparing to 5 to 7 cm of shoulder strap. (Golriz, S., Hebert, J. J., Bo Foreman, K., & Walker, B. F., 2017). In this study, the width of shoulder strap for AGS-backpacks are 5.5 cm and the width of control backpack is 6 cm. The width of control backpack is wider than AGS-backpacks. Wider shoulder strap was able to disperse the carrying weights. Therefore, the width of shoulder strap was the factor affecting the shoulder pressure measured.

Standard deviation on control backpack

The values of the standard deviation (SD) would be a question to the reliability of the study. In table 1, there is an obvious difference on standard deviation between control and AGS-backpack. The SD of control backpack in P1 to P4 were higher than AGS-backpacks, for examples in P1, the SD of control and new-AGS are 3.5 and 1.6, which was a huge difference. High value of SD indicated that the data were spread out over a large range of value. There were differences on measured interface pressure for same backpack between subject and subject, and even between test and test for the same subject, especially for the control backpack. It also affects the result of the study, one of the reasons why the result was not positive.

Different approach on data analysis

In the data analysis of this study, another approach on data analyze could be done. In this study, only the peak and bottom interface pressure in a gait cycle were input to analysis and compare. It is no doubt that interface pressure applied on the shoulder was recorded and analyzed. The results also showed that AGS-backpack unaffected the pressure applied on the shoulder under the study. However, the duration of the interface pressure applied to the shoulder was ignored. It means how long the shoulder was being applied by the pressure. The measured pressure in the resting time could be an average of the whole test. Then, the amounts of duration when the interface pressure above and below the average line could be calculated. it provides a specific calculation on the amount of the interface pressure instead of the vertex of measured interface pressure. After that, the result could be used to compare the amount of interface pressure above and below the average. By comparing to the result of ordinary backpack, it could be used to show any difference between the ordinary backpack and AGS-backpack on relieving the shoulder-interface pressure.

Gait cycle

Analyzing the data in gait cycles is good way to present and discuss. In this study design, the data analysis was conducted into 50 gait cycles. The data sets were clearly sorted to 50 gait cycles and there were analyzed and compared to different backpack by each gait cycle. During the walking time in 90s, gait cycles were recording. The research reported that interface pressure measured had shown to be adequate throughout the gait cycle. (Martin and Hooper, 2000) Apart from that, starting from left or right foot have slightly difference on the measured interface pressure. In this study, it didn't show the significant difference in a gait cycle to recognize the starting foot. However, there are slightly difference on the starting foot in a gait cycle. Starting your gait by left foot increase your left

shoulder pressure, which may affect the accuracy and consistency in the study.

The data of walking time were captured to data analysis in this study. There were only 50 gait cycles includes P1 to P4 were generated. In fact, there were more than 50 gait cycles could be generated during the 90 seconds. Supposedly, 50 gait cycles should be enough to reflect the interface shoulder measured and compared to different backpacks. On the other hand, the resting time in the beginning and in the end were excluded in the data analysis. To ensure the stability of the data collection, participants were required to stand still for 30 seconds in the beginning and in the end of the test.

Different duration and loads

Different duration and loads must be adjusted to test the effectiveness of AGS-backpack under different situation. The duration and loads mean the distance and the weight the subject is going to carry with a backpack. The research found that the muscle fatigue was found from 10min with 15% body weight evaluating by the shift of median power frequency. The increased of muscle activity was already found from 5min, it showed that the muscle fatigue increase by longer time carrying backpack. (Hong, Y., Li, J. X., & Fong, D. T. P., 2008.) Therefore, there is a possibility that AGS-backpack may relieve the interface pressure on the body as time goes on. AGS-backpack also claimed that there is perceived exertion reduced by Borg Rating of Perceived Exertion scale (RPE) when carrying AGS-backpack after 30min. (Yang, X., Wai, Z. H. P. T. N., & Li, F. K. Y., 2020). On the other hand, even though 10% of body weight is generally accepted as a recommended maximum load for the users, research showed that most of the students in Hong Kong carried over 10% of their body weight daily. (DAB Family Affairs Committee, 2018) There is a necessary to study a higher backpack loading for the real-situation whether AGS-backpack is possible to ease the interface pressure with heavier loadings.

Walking speed

Apart from the duration and speed, there is a relation between walking speed and AGS. Anti-Gravity system only would be activated when the user is walking. In this study, it showed that the interface pressure was fixed when the participant stood still. When the participant started walking, AGS were activated and there is a bouncing motion behind. The increased walking speed are more likely to activate and foster up and down motion on the AGS. By comparing to the ordinary backpack, it is another aspect to evaluate the function and effectiveness of AGS-backpack.

Different sensor location

Different locations on the body are worthy to study, for examples axillary area, which is reported that the relation between shoulder strap width and axillary-interface pressure when carrying a backpack. (Golriz, S., Hebert, J. J., Bo Foreman, K., & Walker, B. F., 2017.) Increased measured spots are more likely to present a comprehensive study to show the effectiveness of AGS-backpack. Apart from the location placed on different spots, the clothing also is another factor in the study. To ensure the consistency of the study, the participants were required to take off their shirt during the whole study on the treadmill. However, some findings suggested that interface pressure measurement are unaffected by layers of clothing, which means the interface pressures can be measured above clothing layers rather than having to be at the skin surface. (Jones, G. R., & Hooper, R. H., 2005.)

Posture, loads placement

The loads placement is a factor affecting the results. In this study, the weight plates were adapted to adjust the equivalent loads to 6.9kg of three backpacks, and all of it placed close to the back. Research reported that the loads placement influenced the posture and higher oxygen consumption when carrying the heavy items, especially loads in the upper position when walking at the high grade. (Liu, B. S., 2007., Mackie, H. W., Stevenson, J. M., Reid, S. A., & Legg, S. J., 2005). Therefore, loads placement may influence the interface pressure and it is suggested that the location of loads should be placed closer to our back to reduce the injury and energy expenditure. In this study, the load placement was in the low spaces of backpack instead of high spaces of backpack. Research reported that high load placement caused lower shoulder pressure, higher axilla shoulder pressure. In contrast, low load placement resulted in higher shoulder pressure and lower axilla shoulder pressure. The consistency of this study is good, but the location of loads placement in this study may affect the measured shoulder pressure when comparing to the different loads' placement in the backpack.

Recommended threshold of shoulder pressure

Research indicated that 14 kPa is considered as the safe upper limit and it's the recommended threshold which has been reported to cause tissue damage. (Doan, J. B., Stevenson, J. M., Bryant, J. T., Pelot, R. P., & Reid, S. A., 1998). Based on this study, taking 10% of body weight to analysis the shoulder pressure on three backpacks, the results showed that there hadn't exceed the threshold which is 14kPa as recommended. In P2 and P4 which were the vertex of measured pressure, shoulder pressure measured resulted below 12 kPa for three backpacks. Therefore, even though there was no

difference between three backpacks, but the result showed that it was the safe range when carrying the backpack within 10% body weight.

The orders of the study

The influences of the orders for carrying the backpacks in the test. In this study, there were not fixed orders for the subject to carry which backpack first. it affected the consistency of the study, random orders for the participants to carry the backpacks in the study. The participants didn't know the information of three backpacks before or during the experiment. there was no subjective influence on the study. However, there is possibility affecting the result or performance of the subjects because there was no fixed order for subjects in the experiment.

8. Limitations

There are four limitations in this study, including the samples sizes, shoulder strap, sensor location and how to activate AGS-backpack.

Sample sizes

First, the sample sizes were not big enough, there were only 15 subjects recruited in this study. To estimate the accurate sample sizes in the study, G*power or other software are expected to be used for calculating the sample sizes. The goal of a sample size calculation is to conduct the number of subjects needed to be detect a clinically relevant treatment effect. It was suggested that to complete a sample size calculation on every study. (Nayak, B. K., 2010) Instead of calculated sample size, 20 participants were designed for the study originally. However, the study was stopped and only 15 participants were completed the study under covid-19 pandemic.

The length of shoulder strap

The interface-shoulder pressure would be affected by the length of shoulder straps. The research showed that the length of shoulder strap adjustment has a significant effect on their shoulder pressure. it is suggested to allow a reasonable amount of looseness in the shoulder straps. (Mackie, H. W., Stevenson, J. M., Reid, S. A., & Legg, S. J., 2005). However, the lengths of shoulder strap in the study could not be fixed because there is the diversity of body types. There were different body types of the participants in the study, the lengths of shoulder strap were not able to be fixed which may cause discomfort to the subjects.

Sensor location

The sensor for measure interface-shoulder pressure was located under the left shoulder strap of the backpack. The sensor we adapted in the study is an 8mm miniature force sensor, which is a tiny sensor. Even though there was marker to remark the location of sensor placed, to ensure the same position for each participant, but there was not a fixed location between subjects. Different body types would affect the location of the shoulder strap; therefore, the participants were suggested to carry the backpack by their own experience and the sensor was placed under the shoulder strap once they were ready. Thus, the sensor was fixed by tape to ensure the location would not be moved during the whole test.

How to activate the AGS

The results showed that there were differences and variation over each type of backpack. Based on raw data and after data analysis, statistical dispersion was found in each subject. One of the possible reasons is how you carry the AGS-backpack. The difference between AGS-backpack and ordinary backpack is the spring installed behind, it creates up and down and bouncing motions when the user is walking. However, there are tempo and rhythm of AGS which are required to activate. Thus, different loads in the backpack are the factor of activating AGS. Based on Law of action and reaction, heavier loads create a greater action, and the reaction was given to create an upward motion. Therefore, it is necessary to study heavier loads on AGS-backpack to find out any changes or differences between AGS-backpack and ordinary backpack.

AGS-backpack start bouncing when you are walking, your shoulder should go the same direction as the backpack goes. Otherwise, it may increase the shoulder pressure in contrast or caused the variation between test in same subject.

9. Conclusion

The current study has shown that there are not significant differences between control backpack and AGS-backpacks. In this study, research revealed that there are many factors related to the measurement of the interface shoulder pressure, including the width of shoulder strap, the duration and loads of carries. They may influence the result and therefore, further study from different aspects were needed to find out the effectiveness of AGS-backpack. Apart from the effect of an AGS-backpack, we suggested that the least loads possible in your backpack for the sake of body posture and health.

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