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AN ERGONOMIC APPROACH TO LAPTOP BACKPACK TO REDUCE PHYSIOLOGICAL COMPLAINTS AND INCREASE PRODUCTIVITY

**Bagus Arbi ADRIANTO, Nyoman ADIPUTRA,
Ketut TIRTAYASA, I Putu Gede ADIATMIKA**

Abstract: *Many pieces of research on the disadvantages of using laptops have been carried out, namely causing neck flexion, rotational force, and physical discomfort in using a laptop. The aim of this research was to investigate the benefits of a Laptop backpack to reduce physiological complaints and increase productivity. The number of participants in the sample was 24 individuals, of which 12 individuals used laptop backpacks and the rest did not. Based on the results of research on Design Laptop Backpacks it was found that laptop backpack designs based on a total ergonomics approach could reduce physiological risks in the form of decreasing fatigue, musculoskeletal complaints, eye complaints, increased productivity and improved time efficiency for visual communication design students ISI Denpasar. The students' fatigue level was reduced by 6.4%, musculoskeletal complaints were reduced by 9%, and eye complaints were reduced by 28.39%, while productivity was increased by 32.35%. It was found that laptop backpack reduces physiological complaints and increases productivity.*
Key words: *Total ergonomic approach, fatigue, musculoskeletal complaints, eye complaints, productivity.*

1. INTRODUCTION

The use of laptops has grown in all aspects of life. Students have a pattern of behavior of using laptops to do their assignments in a sitting posture that is not physiological, i.e. sitting hunched over in a chair without a backrest as support, which is done continuously over a long period of time. This is true as the students of visual communication design spend on average 10 hours typing their assignments outside the time they spend on attending lectures. Sitting for a long time and improper sitting posture, as well as too much activity, are some of the factors that cause lower back pain. Sitting for 15-30 minutes can cause uncomfortable conditions and therefore 5 minutes of movement are needed in between sittings [1]. According to Manuaba [2], this can cause osteoporosis and pain in the neck, hind head, and back. Premature fatigue in workers can cause work-related diseases and work accidents that can result in disability and even death [1].

The component of a workstation that receives the highest priority is the position of the feet being lifted off the floor (97%), which means that blood flow and nerves in the thighs can be blocked due to continuous stimulation. A chair that has no backrest (72%) creates ergonomic problems such as non-physiological postures of the shoulders, hands, wrists, and neck. Unavailability of a document holder (63%) means that some students experience pressure while working with their laptops and at the same time viewing documents. The eye and neck movements can cause physiological complaints. The unavailability of an external mouse (60%) can cause shoulder and neck pain.

The laptop feature that receives the highest priority is the monitor light which is excessive and is not adjusted to the eyes, causing eye complaints among students (66%). Next is the heat emitted from the laptop (62%). Reflection of sunlight or lights onto the monitor screen can create glares (60%).

In students' interactions with laptops, a component that receives the highest priority is the conventional workstation that is not ergonomic (68%). Using a conventional workstation causes non-physiological posture of the body (62%). Conditions that are not physiological can cause complaints in the lower back of laptop users for a long period of time, causing pain in the back, spine, and waist.

Another mistake in using a laptop is that it is placed on the lap, which causes heat and damages the thigh nerves, as well as interferes with the reproductive organs. In terms of the environment, the materials used in the holistic approach to the design of a laptop backpack based on the total ergonomics approach are specially selected materials so that they are environmentally friendly and can be recycled because they use fiber and fabric materials. Environmentally friendly materials do not have a bad impact on human life, so they are safe to use for both short and long periods of time.

As a result of the existing conventional workstations, there are several physiological complaints that are experienced by students of visual communication design, which consist of fatigue, musculoskeletal complaints, and eye complaints.

Based on these physiological complaints, a holistic approach was made to the design of the laptop backpack based on the total ergonomics approach with various features incorporated. Before it can be produced and sold, there is an analysis of costs and benefits that must be considered, including costs of materials, work processes, labor costs, and so on, so that it can increase productivity, which is seen from the increased product outputs in terms of quantity, quality, and the lead time, and from the increased productivity of students as users.

The research conducted by the authors had concluded to design a laptop stand that is used by users by standing and sitting but does not have a seat. Use in a standing position can cause fatigue in the leg and hip muscles, while the use of a sitting position causes fatigue on the back, arms, and shoulders, besides that it does not have a document holder or mouse pad. The table is too narrow and cannot be used in all conditions. In his research, he concluded that standard laptop tools were not perfect but were sufficient to help the use of laptops in a standing position, 107 cm high, 81 cm in sitting position, 53 cm long base, 33 cm wide for laptop holder, and 28 cm for the length of the bottom support for the laptop. Furthermore, [3] in their research results found that workers endure pain in the neck, back, hands and feet during and after work reaching 42%, 6%, 26% and 26% of the activities carried out in category 1, category 1. 2, category 3 and category 4. Based on this, it is deemed necessary to create ergonomic tools that can be used by laptop users that are easy to carry anywhere and provide comfort.

It is necessary to conduct research on the holistic approach made to the design of laptop backpacks based on the total ergonomics approach for two purposes, firstly to reduce physiological complaints which can be assessed based on the variables of fatigue, musculoskeletal complaints, and eye complaints, and secondly to increase productivity and increase time effectiveness.

2. MATERIALS AND METHODS

Making a laptop backpack design begins with the discovery of problems in students with non-ergonomic work positions when doing assignments.

Followed by designing the idea of the shape and model of the laptop backpack and with experts in the field of design to realize the manufacture of the product to the finishing stage. Laptop backpack weight 2.08 kg without laptop, and with laptop 4.08 kg. The product results are in Figures 1a to 1d.

Fig. 1. Backpack design: a. outer bag; b. inner bag; c. portable desk (inner bag); d. portable backrest (outer bag).

Fig. 2. Use of ergonomic laptop backpack: a. ideal body weight man; b. ideal body weight woman; c. overweight person.

Figures 2a to 2c showed the use of an ergonomic laptop backpack for people with ideal body weight in man and woman, and overweight people, meaning that the resulting product could be used safely even if people are overweight (obese).

3. RESEARCH DESIGN AND RESEARCH SAMPLE

Measurements were carried out at ISI Denpasar at a temperature of 27˚C [4], a humidity of 30-45% RH, light intensity of 500 lux (lux meter), a wind speed of 0.2 m/s, and noise intensity of 45 dB. Measurements were carried out from October 2019 to April 2020. A sample of 24 individuals aged 18-19 years participated in the study. The sample consisted of students of visual communication design at ISI Denpasar. They were randomly divided into two groups, namely the group that used laptop backpacks and the group that did not use laptop backpacks.

Measurements began at 08.00 to ensure the same level of fatigue among the participants. The control group did not use a laptop backpack during work, so they sat hunched over without a backrest. The treatment group sat with a backrest. The researchers monitored the movement of the participants. The participants were not allowed to have any discussions during the study.

The measurement process involved the following steps:

1. The participants were advised to engage in moderate activities while outside of class hours during the course of the research.
2. The participants were required to arrive on campus at 07.00 Central Indonesia Time, so that when filling out the questionnaires at 07.10 Central Indonesia Time, they would already be refreshed physically.
3. The control group worked on a conventional workstation.
4. The treatment group worked on a laptop backpack based on the total ergonomics approach.
5. Data from Control Group 1 were collected 4 days a week (from Monday to Thursday), as follows:
   a) At 07:00 the participants sat in their chairs, and received breakfast that was distributed to them (consisting of one slice of whole wheat bread, nuts, eggs, vegetables, one slice of fruit, as well as 1 cup of 220 ccs sweet tea) so that the initial conditions were homogeneous. Research members gave a brief introduction, and then at 07:10 the students filled out the following questionnaires: (1) Questionnaire of 30

items on the level of fatigue on a 4-point Likert scale; (2) Questionnaire of 28 items on the level of musculoskeletal complaints using Nordic Body Map on a 4-point Likert scale; (3) Questionnaire of 9 items on the level of eye complaints on a 4-point Likert scale. The questionnaires were saved as data before working 01 and 03;

b) At 07:20 Central Indonesia Time, the work environment was measured using the environmental meter, at one point on a table surface in the middle and four points at the corners of the diagonal lines, with the meter being placed near the students working;
c) From 07:30 to 10:00 Central Indonesia Time, the participants typed their assignments, and all activities were recorded using a video camera;
d) At 10:00 Central Indonesia Time the participants filled out the following questionnaires: (1) Questionnaire of 30 items on the level of fatigue on a 4-point Likert scale; (2) Questionnaire of 28 items on the level of musculoskeletal complaints using Nordic Body Map on a 4-point Likert scale; (3) Questionnaire of 9 items on the level of eye complaints on a 4-point Likert scale. The questionnaires were saved as data after working 02 and 04;
e) From 10:10 to 10:30 Central Indonesia Time all participants had a break. The situation during the break was recorded using a digital camera;
f) At 10:00 Central Indonesia Time the same measurements as those in point b were conducted;
g) At 10:30 Central Indonesia Time the participants filled out the following questionnaires: (1) Questionnaire of 30 items on the level of fatigue on a 4-point Likert scale; (2) Questionnaire of 28 items on the level of musculoskeletal complaints using Nordic Body Map on a 4-point Likert scale; (3) Questionnaire of 9 items on the level of eye complaints on a 4-point Likert scale. The questionnaires were saved as data before working 01 and 03;
h) At 10:30 Central Indonesia Time, the same measurements as those in point b were conducted;
i) From 10:40 to 12.30 Central Indonesia Time the participants typed their assignments, and all activities were recorded using a video camera;
j) At 12:30 Central Indonesia Time the participants filled out the following questionnaires: (1) Questionnaire of 30 items on the level of fatigue on a 4-point Likert scale; (2) Questionnaire of 28 items on the level of musculoskeletal complaints using Nordic Body Map on a 4-point Likert scale; (3) Questionnaire of 9 items on the level of eye complaints on a 4-point Likert scale. The questionnaires were saved as data after working 02 and 04;
k) At 12:30 Central Indonesia Time the same measurements as those in point b were conducted;
l) After measurements were completed, the activity of collecting data ended.

6. The data collection conducted on Control Group 2 was in principle the same as the data collection conducted on Control Group 1, which used a laptop backpack based on the total ergonomics approach.

4. RESULTS

Based on the description, the researchers would like to present an analysis of the research variables in relation to the independent variables of physiological complaints and productivity (Paired t-test and Wilcoxon), as well as the differences between the control group and the treatment group (independent t-test).

4.1 Physiological Complaints

The results show that there was a significant difference in physiological complaints based on the fatigue variable. The decrease that occurred was 6.84% (Table 1). There was also a significant difference in musculoskeletal complaints with a percentage decrease of 9.89% (Table 2). A significant difference was also shown in terms of eye complaints between the treatment group and the control group, where the decrease was 39.64% (Table 3).

Table 1

Results of The Comparison Test of Fatigue Data on Experimental Group Design and Control Group Design

Fatique	*n*	KP1	KP2	Diff.	*Independent T-test P*
		Average ± SB (score)	Average ± SB (score)		
Before Work	12	33,50 ± 0,46	33,19 ± 0,43	0,31	0,110
After Work	12	36,86 ± 0,77	34,50 ± 0,33	2,36	0,000
Different	12	3,36	1,31	2,01	0,114

Level of significance p value < 0,05

Table 2

Results of The Comparison Test of Musculoskeletal Complains Data on Experimental Group Design and Control Group Design

Musculoskeletal Complains	*n*	KP1	KP2	Diff.	*Wilcoxon Test*
		Average ± SB (score)	Average ± SB (score)		*P*
Before Work	12	28,16 ± 0,39	28,08 ± 0,28	0,08	0,317
After Work	12	70,33 ± 1,97	64,00 ± 2,29	6,33	0,002
Different	12	42,17	35,92	6,25	0,315
P		0,005	0,000		

Level of significance p value < 0,05

Table 3

Results of The Comparison Test of Eye Complains Data on Experimental Group Design and Control Group Design

Eye Complains	*n*	KP1	KP2	Diff.	*Wilcoxon Test*
		Average ± SB (score)	Average ± SB (score)		*P*
Before Work	12	10,08 ± 0,40	9,80 ± 0,35	0,28	0,123
After Work	12	14,69 ± 0,26	10,52 ± 0,22	4,17	0,002
Different	12	4,61	0,72	3,89	0,000
P		0,002	0,002		

Level of significance p value < 0,05

Table 4

Results of The Comparison Test of Productivity Data on Experimental Group Design and Control Group Design

Productivity	*n*	KP1	KP2	Diff.	*Wilcoxon Test*
		Average ± SB (file/pulse)	Average ± SB (file/pulse)		*p*
Before Work	12	0 ± 0	0 ± 0	0,00	1,000
After Work	12	0,23 ± 0,028	0,34 ± 0,017	0,11	0,002
Different		0,23	0,34	0,11	
p		0,002	0,002		

Level of significance p value < 0,05

4.2 Productivity

The results show a significant difference with an increase of 47.83% (Table 4). There was a significant increase in time effectiveness with a percentage increase of 73.05%.

5. DISCUSSION

The aim of the study was to investigate if laptop backpack reduces physiological complaints and increases productivity. Sitting hunched over while doing assignments is an unergonomic position and can cause fatigue, musculoskeletal complaints and eye complaints [5-7].

The results show that there was a significant difference in fatigue between the treatment group and the control group. The average level of fatigue in the control group was higher than that in the treatment group. The decrease in fatigue experienced by students is the result of improved working conditions with the total ergonomics approach [8-13]. The use of a laptop backpack allowed the students to work on their assignments without repetitive changes in working positions because the laptop base reduces heat, therefore reducing the burden of the muscle to bear the weight of the laptop. The backrest kept their positions more upright, and the use of the mouse pad made more effective use of time. The addition of a document holder was able to minimize the movement of the neck muscles when looking at texts or assignments and therefore reduced fatigue in the neck muscles.

The decrease in musculoskeletal complaints created a significant difference between the control group and the treatment group. The average number of musculoskeletal complaints in the treatment group was lower than that in the control group, with the decrease being 9.89% [14-19].

The decrease in musculoskeletal complaints was the impact of ergonomic interventions including the use of a laptop backpack because of a natural and more physiological work posture, which causes reduced stretching and pressure on tendons, nerves, and blood vessels, so that blood circulation to active muscles becomes unobstructed. With good blood circulation, the accumulation of lactic acid and body temperature decreases. Ultimately, complaints of muscle fatigue that are felt as

muscle pain or musculoskeletal complaints can be reduced [6], [20-24].

The use of a laptop backpack based on the total ergonomics approach can reduce musculoskeletal complaints among students. This is because there is a backrest in place that enables students to have a more stable and not slouched position so that the spine and upper back and neck muscles are more relaxed throughout their time working on the assignments. The use of a laptop table can also help to hold the laptop so students do not need to use their leg muscles to withstand the weight of the laptop being used. The mouse pad used by students can be used as a pad to reduce pain in hand muscles such as wrists and fingers when using a mouse. The document holder is also an important component because it reduces eye and head movements in viewing the documents being worked on, so that the students can look in the same direction toward the document holder and the monitor screen, thereby reducing complaints in the neck muscles.

The decrease in musculoskeletal complaints is a result of the reduction of repetitive movements when typing, with a moment for light stretching given every 30 minutes when doing assignments, so that physiological changes are not too high. High physiological changes cause high level of fatigue in the muscles as well. Although when doing assignments there are no high physiological changes, stretching is an activity that is consistently carried out in helping muscles to continue to relax. The decrease in musculoskeletal complaints is also due to the additional nutritional intake by the students by consuming sandwiches and sweet iced tea, which can provide energy to the muscles. The energy that is provided is able to compensate for the lost energy after having been used up so that the body is stimulated to be more energized. Efforts to reduce musculoskeletal complaints are also carried out by managing break time. Taking short breaks in between tasks can provide a burst of energy. A short break is a moment of a short pause to get away from the desk or workplace. Short breaks can be used to increase nutritional intake, talk to coworkers, and stretch out.

The results of the study on eye complaints show that there was a significant difference in eye complaints between the control group and the treatment group, where the average number of eye complaints in the treatment group was lower, with a decrease of 39.4%. It can be said that the use of a Laptop backpack based on the total ergonomics approach has been shown to reduce eye complaints among students. This decrease occurred because of a decrease in fatigue scores before and after using a laptop backpack based on the total ergonomics approach [9, 20, 25-29].

Eye fatigue also decreased because of stretching after working for an hour by shifting their gaze to green objects or looking at the outdoors. In addition, it is also a result of closing the eyes for 5-10 minutes so that the eyes become more relaxed before looking back at the monitor screen when doing assignments. Eye fatigue can also be reduced by taking short breaks while working on assignments, because a 5–10-minute break is a very beneficial time if used properly, meaning that students can improve their posture and give their eyes a chance to have a rest from the laptop screen and reduce eye strain. Short rest periods can be useful in maintaining the energy levels in the body to be able to resume activities. Supply of additional nutritional intake when doing assignments can also affect the reduction of eye fatigue, because the nutritional content in sandwiches provides energy and carbohydrates that muscles need when working, including eye muscles. Eyes can be relaxed by shifting their focus to other objects such as green sights, which can reduce eye fatigue.

The results of the research show that there was a significant difference in students' productivity between the control group and the treatment group. The average productivity was higher in the treatment group with an increase of 47.83%. This increase occurred due to the increase in the number of texts typed and completed by students, which were completed as a result of decreasing health problems among the students. The results of this study prove that working conditions are improved for students by using the ergonomic laptop backpack which increases productivity [9, 14, 15, 30-32].

The increase in productivity occurred due to the resolution of problems found by using the SHIP approach which was applied in the use of

effective technology. The application of the SHIP approach includes varied work positions, dynamic work movements, upright working postures while sitting in chairs, and eliminating inefficient movements. In addition to changes in working conditions, there was also a supply of additional nutrition in the form of sweet tea and sandwiches [33-35].

After using a laptop backpack based on the total ergonomics approach, students had increased productivity which can be seen from the number of assignments that were completed. The increase in productivity was due to the use of a laptop table that reduces the weight of the laptop on the leg muscles, the use of a backrest that provides a more ergonomic sitting position, a mouse pad that reduces hand and finger muscle complaints, and the use of a document holder that reduces eye complaints, so that all components used can reduce complaints and overall fatigue so that the body becomes more relaxed and can concentrate for a longer time to complete assignments. Stretching during work is able to nourish the body, especially for laptop and computer users, because it can improve blood flow. Working too long in the same position will hamper blood circulation and potentially trigger high blood pressure. Stretching is beneficial for maintaining balance and body coordination, reducing pain in the arms, back, and legs, and reducing stress because good blood circulation can better distribute oxygen and nutrition to the brain. Short breaks also have a positive impact on productivity and work ability in completing assignments, because when the body is resting it is making efforts to maintain existing energy so that it can be reused after resting. During rest periods, students can stretch their muscles and consume snacks to be able to replenish the energy that has been used up, as well as communicate with other people, which can help create a positive mood before resuming the assignments that must be completed. The good and sufficient nutritional status will provide a lot of support in doing activities. Although working in a sitting position, one still needs adequate nutrition when doing their tasks. Likewise, students who are doing their assignments really need additional energy intake. The supply of sandwiches and sweet iced tea can increase their productivity because the energy and carbohydrate content of the food and drink consumed is quite high.

An increase in productivity is an indication of the effective time used as evidenced by a significant difference in the use of time. The average time used by the treatment group was less than that of the control group, where the percentage increase was 47.83%. The results of this study prove that improving working conditions for students by using the ergonomic Laptop backpack increases productivity [9, 14, 15, 30, 31, 36].

6. CONCLUSION

Based on the results of the analysis, it can be concluded that there is a significant difference in decreasing fatigue before and after work ($p < 0.05$), the average fatigue in the control group after using a backpack is 36.86 while in the treatment group it is 34.50. Measurement of fatigue after work shows a decrease in score of 2.36 or a decrease of 6.4%.

There was a significant difference in the decrease in musculoskeletal complaints before and after work ($p < 0.05$), the mean musculoskeletal complaints in the control group after using a backpack was 70.33 while in the treatment group it was 64.00. Measurement of musculoskeletal complaints after work showed a decrease in score of 6.33 or a decrease of 9%.

Measurement of eye complaints after work showed a decrease of 4.17 or a decrease of 28.39%. The results of statistical analysis showed that there was a significant difference in the mean score between the two KPs ($p < 0.05$), namely laptop backpacks based on a total ergonomics approach that reduced eye complaints more than conventional workstations.

The results of the measurement of student productivity in KP1 and KP2 showed a difference of 0.11 files/beat or an increase of 32.35%. The results of statistical analysis showed that there was a significant difference in the mean score between the two KPs ($p < 0.05$), namely laptop backpacks based on a total

ergonomics approach that increased productivity more than conventional workstations.

The results of measuring the effectiveness of time for students in doing assignments in KP1 and KP2 showed a difference of 2 days or an increase of 42.21%. The results of statistical analysis showed that there was a significant difference in the mean score between the two KPs ($p < 0.05$), namely laptop backpacks based on a total ergonomics approach that increased time effectiveness greater than conventional workstations.

ETHICAL APPROVAL AND CONSENT TO PARTICIPATE

This study was submitted as Project No. 2009.03.1.1161, and has been approved by the Ethics Committee of the Department of Occupational Physiology and Ergonomics, Faculty of Medicine, Udayana University. Informed consent was obtained from each participant.

There are no potential conflicts of interest reported by the authors.

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O abordare ergonomică privind rucsacul pentru laptop cu scopul de a reduce simptomele fiziologice și pentru creșterea productivității

Rezumat: Numeroase cercetări indică faptul că flexia gâtului, forța de rotație și disconfortul fizic sunt dezavantaje ale utilizării laptopurilor. Scopul acestei cercetări a fost de a investiga beneficiile rucsacului pentru depozitarea laptopului, pentru a reduce simptomele fiziologice și a crește productivitatea. Numărul de participanți în cadrul cercetării (eșantionul) a fost de 24 de persoane, dintre care 12 persoane au folosit rucsac pentru laptop, iar restul nu. Pe baza rezultatelor cercetărilor privind proiectarea unui astfel de rucsac s-a constatat că rucsacurile pentru laptop proiectate pe baze ergonomice ar putea reduce riscurile fiziologice sub forma reducerii oboselii și afecțiunilor musculo-scheletice în rândul studenților din cadrul ISI Denpasar. Nivelul de oboseală al studenților a fost redus cu 6,4%, afecțiunile musculo-scheletice au fost reduse cu 9%, iar diconfortul ocular a fost redus cu 28,39%, în timp ce productivitatea crescut cu 32,35%. S-a constatat că rucsacul pentru laptop reduce simptomele fiziologice și crește productivitatea.

Arbi ADRIANTO, PhD Student, lecturer, Trisakti University, espring.atmosphere@gmail.com, Apart. U Residence Lippo Karawaci tower 5 Biz loft unit 1720, Tangerang, Indonesia.

I Nyoman ADIPUTRA, Professor, Udayana University, espring.atmosphere@gmail.com, Apart. U Residence Lippo Karawaci tower 5 Biz loft unit 1720, Tangerang, Indonesia.

Ketut TIRTAYASA, Professor, Udayana University, espring.atmosphere@gmail.com, Apart. U Residence Lippo Karawaci tower 5 Biz loft unit 1720, Tangerang, Indonesia.

I Putu Gede ADIATMIKA, Professor, President of Indonesian Ergonomics Society, Udayana University, ipgadiatmika@unud.ac.id, Jl. Raya Kampus UNUD, Bukit Jimbaran, Kuta Selatan, Badung, Bali 80361, Indonesia