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Scope

ARPN Journal of Engineering and Applied Sciences (ISSN 1819-6608) is an online peer-reviewed International research journal aiming at promoting and publishing original high quality research in all disciplines of engineering sciences and technology. All research articles submitted to ARPN-JEAS should be original in nature, never previously published in any journal or presented in a conference or undergoing such process across the globe. All the submissions will be peer-reviewed by the panel of experts associated with particular field. Submitted papers should meet the internationally accepted criteria and manuscripts should follow the style of the journal for the purpose of both reviewing and editing. Our mission is -In cooperation with our business partners, lower the world-wide cost of research publishing operations. -Provide an infrastructure that enriches the capacity for research facilitation and communication, among researchers, college and university teachers, students and other related stakeholders. -Reshape the means for dissemination and management of information and knowledge in ways that enhance opportunities for research and learning and improve access to scholarly resources. -Expand access to research publishing to the public. -Ensure high-quality, effective and efficient production and support good research and development activities that meet or exceed the expectations of research community. Scope of Journal of Engineering and Applied Sciences: -Engineering Mechanics -Construction Materials -Surveying -Fluid Mechanics & Hydraulics -Modeling & Simulations -Thermodynamics -Manufacturing Technologies -Refrigeration & Air-conditioning -Metallurgy -Automatic Control Systems -Electronic Communication Systems -Agricultural Machinery & Equipment -Mining & Minerals -Mechatronics -Applied Sciences -Public Health Engineering -Chemical Engineering -Hydrology -Tube Wells & Pumps -Structures

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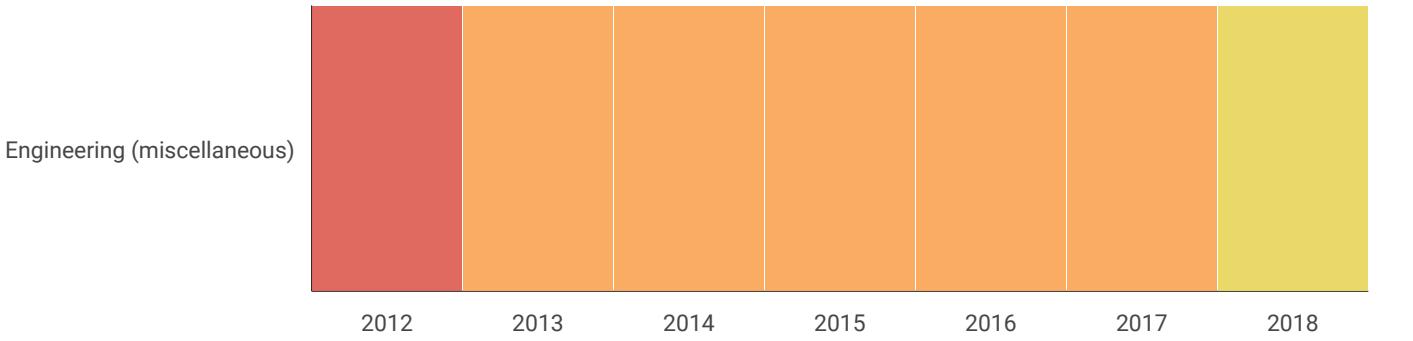

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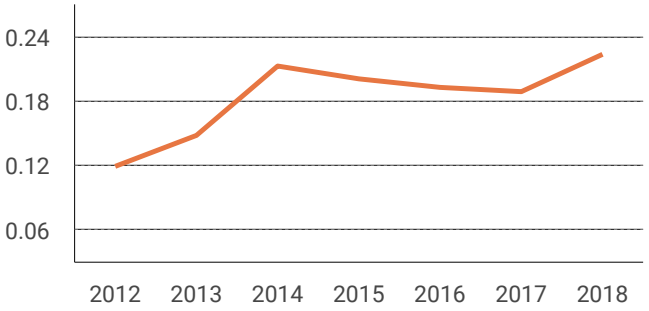

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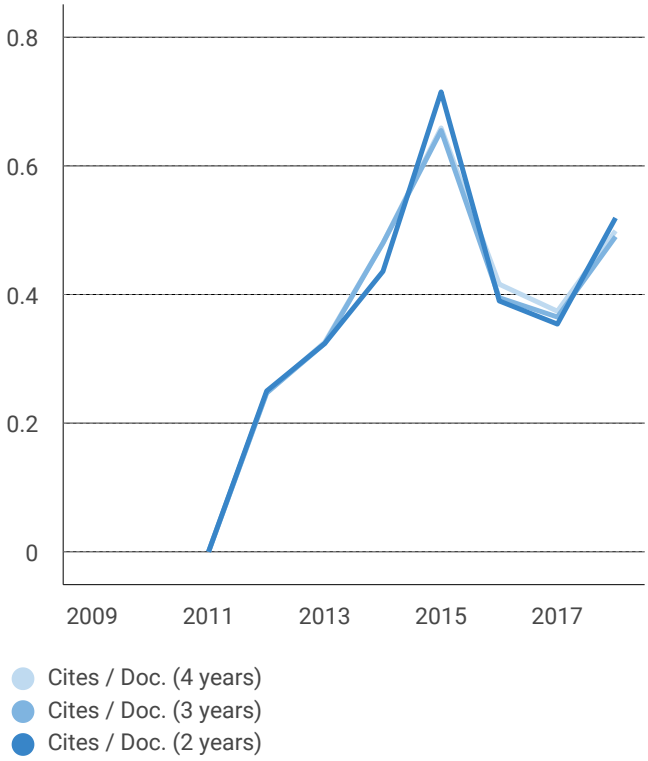

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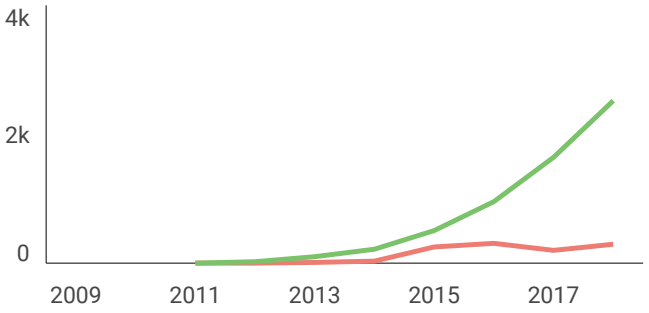

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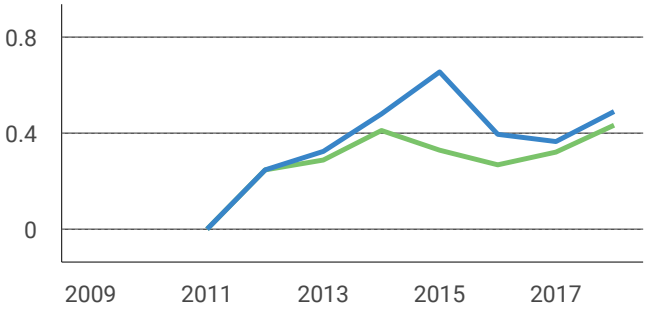

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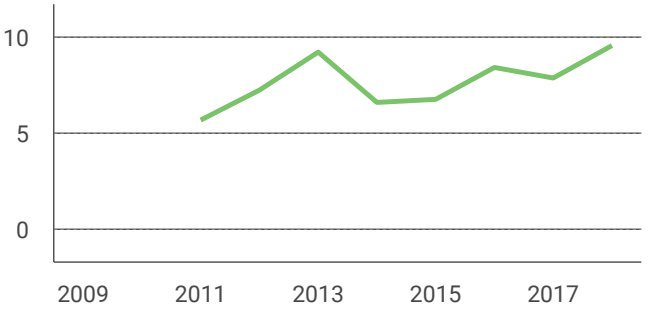

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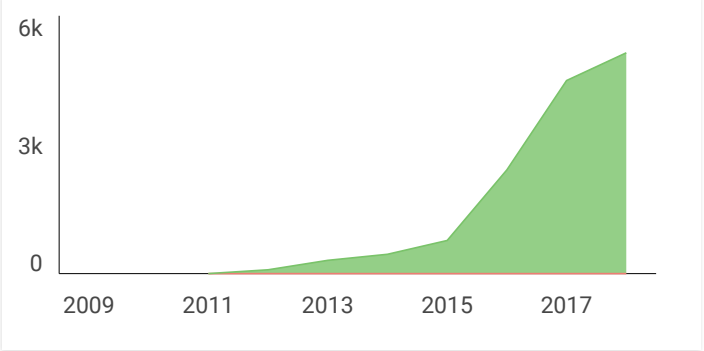

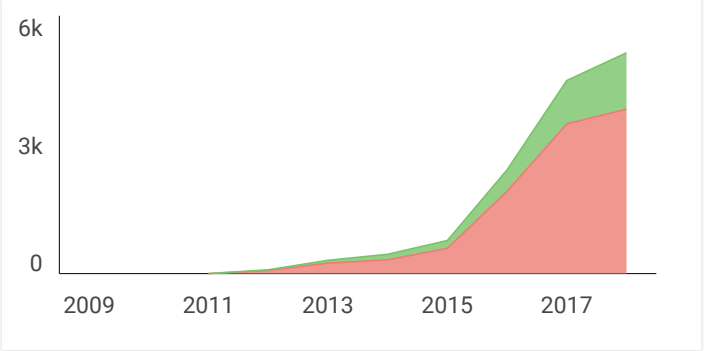

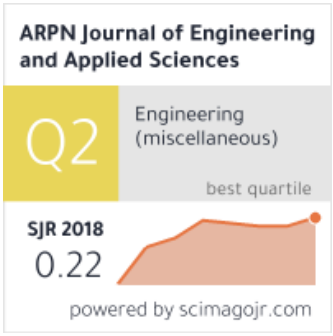

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A **ahmed abed** 2 months ago

it is a predatory journal

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M **M. Fayyadh** 3 months ago

i already submitted my paper to this journal, but afte 7 month the paper was not published, so i email the director and asked the journal why? after two days they asked me to sent my paper again, and after two week i saw my paper is published, so i adivse all of author to email the director direct of his mail if you have any problem

reply

N **neenu daniel** 2 months ago

Please send me director's mail id .

K **Kampala** 2 months ago

Thank you for your advice, I request an his email from you.
Thank you.

O **Oleksii** 2 months ago

Hello! Can you answer me, whether this magazine is quoted in Scopus?
Thank you/
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 **Melanie Ortiz** 2 months ago

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 **Melanie Ortiz** 3 months ago

Dear user, thanks for your participation! Best Regards, SCImago Team

R **Raqeyah Jawad Najy** 3 months ago

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reply

F **Frans** 6 months ago

Dear All
To those who hv submitted jornals whereby they were published but not appeared on your Scopus

profile, please you visit scopus web. A correction help feature included paper that is not appeared, is available. Please make a sure the journal is published and covered by scopus. Thanks

reply

F **Frans** 7 months ago

I think this journal is good enough, the review process is fast and the editor is very communicative

reply

S **samir umana** 6 months ago

Hi, are you sure? i have a paper and it will be a year since it was submitted, please!
i only receive an automatic answer generated by computer.

i am so sad.

D **Dr. Ali Fadhil** 9 months ago

I published My papers in this Journal from 2010, This is good Journals and the publishing time also within good period

reply

B **Baqer Alhabeeb** 7 months ago

It has been classified as a predatory journal.

M **Mahdi** 1 year ago

I am sure this is a fake Journal! Just waste your time ...

reply

A **Abdullah** 6 days ago

I don't think it's a predatory journal or fake journal. This journal is indexed in scopus for last several years.

Z **Zainab H. Mahdi** 1 year ago

On the contrary, this journal sober court within Scopas, and I have all my research published in this journal

 **Elena Corera** 1 year ago

Thank you very much for your participation!

B **Bode Haryanto** 1 year ago

According to my experience, after submitted the paper and send the file bank payment to the journal.they will give the confirmation via email. The submitted paper will get confirmation to fix from the publisher before online. My first paper take about 9 months and 2nd one take about 6 months, never give-up ....

reply

 **Elena Corera** 1 year ago

Thank you very much for your participation!

R **Raj Masum** 1 year ago

I have submitted my paper 5 months ago with processing fee 150$. But I am not getting any reply from the editor except automatically generated email. I think they are just stealing money out of people's pocket. No status update even my paper is not on the under review list. They don't even update the under review and waiting for review paper list. I guess I have lost my money and time. The journal is ruining the image of INDEXING SERVICE. Please ask them to stop playing with people else cancel indexing service of APRN.

reply

H **Houda SALMI** 2 months ago

Hi ,
Could you tell me what about the fees charged, the Journal has stolen the money or it publishes the manuscript?
Thanks a lot

R **Rebecca** 9 months ago

I agree they not reply to the emails, but they say it on their web site to not contact the editor with these questions. The list of articles is just not updated. But my article was published after 7 months.

R **Rafiq Asghar** 1 year ago

I don't have idea, how SCI is indexing that journal. I have submitted paper in January so far no result and their editor not dare to response you on your email. Kindly block it

reply

Y **Youssef EL MOKADDEM** 11 months ago

Hello there,

I just received a confirmation of my article after 4 months, they some comments from the publisher to fixe before online.

Hope it going good for you too,

Best Regards,

Y **Youssef EL MOKADDEM** 1 year ago

Dear Rafiq,

I wonder if you have received feedback on your ARPN article or not yet, since I too submitted an article in early October and transferred the fees to them, and I have not received feedback from the review committee (Except the auto reply).

I remain available if you have any questions,

Best Regards
Youssef

B **Bambang Iskandriawan** 1 year ago

What about the progress of 2 my paper:

1. Energy Consumption Investigation of Local Air Conditioning System In The Apartment Building Unit Through Construction Orientation Review.

2. Design of Air Purifier Bike as The Initiative to Reduce Air Pollution.

Both of them are through International Conference on Mechanical Engineering (ICOME 2017).

Thank you for cooperation.

Regards,

Bambang Iskandriawan

reply

B **Bambang Iskandriawan** 1 year ago

Dear Sir,

Dear Sir,

I just check on
https://www.scopus.com/authid/detail.uri?authorId=56012520900
but my paper was not appear on that.

The title is
ENERGY CONSUMPTION INVESTIGATION OF LOCAL AIR CONDITIONING SYSTEM IN THE APARTMENT BUILDING UNIT THROUGH CONSTRUCTION ORIENTATION REVIEW
VOL. 13, NO. 18, SEPTEMBER 2018
ARPN Journal of Engineering and Applied Sciences

Would you please clarify.

Best regards,

Bambang Iskandriawan

Elena Corera 1 year ago

Dear Bambang,

thank you very much for your comment. Unfortunately, we cannot help you with your request, we suggest you contact journal's editorial staff so they could inform you more deeply

Best regards,
SCImago Team

A

ali fahem 1 year ago

I submitted my paper before 5 months and transfer the fee as the illustration guide but they didn't reply anything to me except the auto replay, they don't have a flexible website no status for reviewing the paper, I didn't recommend publishing in this journal

reply

Y

Youssef EL MOKADDEM 1 year ago

Dear Ali,

I wonder if you have received feedback on your ARPN article or not yet, since I too submitted an article in early October and transferred the fees to them, and I have not received feedback from the review committee (Except the auto reply).

I remain available if you have any questions,

Best Regards
Youssef

Elena Corera 1 year ago

Thanks for your participation!

S **Salah M. Saleh** 1 year ago

review of Double pass solar collector with thermal storage

reply

N **Nabil KHATIB** 1 year ago

am i the only one reiciving an spam email from ARPN telling me to pay the processing charges before getting any decision from the reviewers????

reply

D **DR. PETER ADERONMU** 1 year ago

Two(2) questions: (i) Pls how much is the current publication fees for ARPN Journal;(ii) When is 2018 Journal issue coming out.

reply

Elena Corera 1 year ago

Dear Dr Peter, we suggest you contact the journal directly. Best Regards, SCImago Team

M **Maikudi Musawa** 1 year ago

Hello,

I have forwarded my prof of payment for article processing fee for publication hope you received my e mail regarding that issue.

Thank you.

Maikudi Shehu Musawa.

reply

R

rasha 1 year ago

hi dear
please, I want to know. how much the application fee (cost)?

Elena Corera 1 year ago

Dear Maikudi, we suggest you contact the journal directly. Best Regards, SCImago Team

T

Tom 1 year ago

Dear Hariramakrishnan P and Shiva Shankar R

I submitted an article before 4 months and my article is now online without issue (after the review process). Maybe you could contact directly EDITOR in the Journal. I think SCIMAGO doesn´t have information about each journal in the Elsevier database (payment, review process etc.). SCIMAGO is a good indicator to evaluate journal but I think That's all.

Best Regards
Tom

reply

D

Dwi Jum 1 year ago

Dear Tom
I have some questions for you, because your paper was published on ARPN JEAS. maybe you can share in this forum, what payment system as use to pay APC on ARPN JEAS?
And how long time you get reply about paper status after upload and pay APC (Article Processing Charge)?

Best regards and wishes
Dwi Jum

Elena Corera 1 year ago

Thanks, Tom!

H

Hariramakrishnan P 1 year ago

I submitted a paper 18 months before, till now i did not get any correspondence from the journal except automated reply. Before submission, i sent a mail asking for payment terms,for that only i got reply.

reply

Elena Corera 1 year ago

Dear user, we suggest you contact the journal directly. Best Regards, SCImago Team

S

Shiva Shankar R 2 years ago

how many days it takes to print a paper after submitting.
registration fees how much?
how many days, it takes time to publish i scopus

reply

L

Leo Pestanas 1 year ago

I paid 145GBP to publish my paper and it took almost 9months to appear online. But the hard copy I never received. They will send a confirmation email for the final published appearance and will let you correct it.

S

sam 1 year ago

there is nothing about fee in that link.

Elena Corera 1 year ago

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Elena Corera 2 years ago

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An Ergonomic Evaluation of Mountaineering Backpacks

by Hilma Raimona

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AN ERGONOMIC EVALUATION OF MOUNTAINEERING BACKPACKS

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Department of Industrial Engineering, Faculty of Engineering, University of Andalas, Padang, West Sumatera, Indonesia
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ABSTRACT

Backpack is one of the essential equipment that must be owned by a nature lover or a mountaineer when doing the adventurous activities. There are various types of backpacks on the market with a variety of brands, shapes and sizes according to the desires and needs. However, there are still complaints from the users when or after using those bags. Therefore, this study was conducted to analyse the backpack from the ergonomics side, specifically the influence of the use upon the body muscle and the heart muscle tension on three types of mountaineering backpacks that are often used namely Pack X, Y and Z. This study used Surface Electromyography (EMG) to analyse the muscle activity, Electrocardiography (ECG) to analyse the electrical activity of heart muscle, and Nordic Body Map (NBM) questionnaires to investigate the user perceptions of musculoskeletal discomfort. Twenty nature lover students were participated as the subject in the study. EMG and ECG data retrieval as well as filling out the NBM questionnaire performed before and after simulated trip for an hour using the treadmill in the laboratory by 20 subjects. The results indicated that Pack Z is less ergonomic than Pack X and Pack Y. The study also generates some criteria in choosing the ergonomic backpack based on analysis of muscle and heart electrical activities of the subjects.

Keywords: ergonomic, EMG, ECG, backpack, mountaineering.

1. INTRODUCTION

Adventurous activities, especially climbing or mountaineering, are becoming increasingly popular in Indonesia, especially for young nature lovers. Besides should have strong and healthy body physically and mentally, a mountaineer should also be equipped with convenient and safety equipment, one of them is backpack. This affects the development of mountaineering backpacks design. The design of current high-performance backpacks is very sophisticated with variety of features, sizes, and price. However, preliminary study results show that there are still many complaints from users after using those backpacks.

The preliminary study was conducted in Padang, West Sumatera, to 30 mountaineering backpack users through interviews. It was found that users frequently felt pain in some parts of their body after using the backpacks. The highest complaint perceived by the users is on the right shoulder (90%), on the left shoulder (83.33%), and on the waist (60%).

There is a large body of research addressing the evaluation of backpacks, most of them are backpacks for school children [1]-[4]. Many researchers had studied extensively about the physiological, biomechanical, and psychological effects of different types of backpacks [5]-[8]. Some previous researches also discussed the comparison of some different types of backpacks [9] and [10]. However, there is still lack study in evaluating mountaineering backpacks in terms of ergonomics and make comparison on some types of those backpacks.

A previous study by Retnari *et al*. [11] has been conducted to analysis the use of mountaineering backpack on female mountaineers. The study then designed the ergonomic mountaineering backpack for female mountaineers in Indonesia.

Therefore, this study conducted to evaluate three types of mountaineering backpacks mostly used in Padang, West Sumatera Indonesia in terms of ergonomics. The study also gives some recommendations for choosing or designing ergonomics mountaineering backpacks.

2. MATERIALS AND METHODS

a) Subjects

Twenty nature lover students from University of Andalas, Padang, West Sumatera, Indonesia (10 male and 10 female) participated in the study. All subjects were informed the procedures of the experiment and gave their informed consent to participate in the study. The subjects were healthy and had no acute back or neck complaints which would influence their performance adversely. Their mean (SD) physical characteristics were: age 21.60 (1.82) years, stature 1.64 (0.08) m, body weight 55.65 (9.39) kg.

b) Backpacks

Table-1. Backpack features.

No.	Features	Type		
		X	Y	Z
1	Weight	2,95 kg	5 kg	2,50 kg
2	Height adjustable lid closure	√	√	√
3	Back adjustment system	√	-	-
4	Well-padded shoulder strap	√	√	√
5	Sternum strap	√	√	√
6	Well-padded waist strap	√	√	√
7	Breathable back system	√	√	-
8	Internal contoured frame design	√	√	√
9	Material	*Duratex*	*Cordura 500D, Cordura 1000D*	*Full Cordura*

Three high-performance and internationally renowned mountaineering backpacks with 60 litre average volume were used. Pack X was manufactured in Germany, while Pack Y and Z were manufactured in Indonesia. The features of each backpack were presented shown concluded in Table-1. Those backpacks were chosen because they were the most likely to be used by the respondents in Padang, West Sumatera, Indonesia.

c) Instrumentations

Cobra 4 Sensor-Unit Electrophysiology: Electrocardiography (ECG) and Electromyography (EMG) System complete with disposable surface electrodes Ag/AgCl/Solid adhesive pre-gelled were used to record the electrical activity of heart and muscle. Data obtained was then analyzed using Cobra4 software from PHYWE System GmbH and Co.KG.

d) Experimental design

Each subject simulated a climbing trip with walked for an hour on a treadmill at 3 km per hour with various tilt angles. The experiment was carried out in Laboratory of Work System Design and Ergonomics, Department of Industrial Engineering, University of Andalas, Padang, West Sumatera, Indonesia. In the first 10-minute, the walk was conducted at the angle of 0^0, then, in the second 10-minute, the walk was conducted at the angle of 4^0. The third 10-minute, the walk was conducted at the angle of 8^0, and 30 minutes later, the walk was conducted at the angle of 10^0. The subjects were measured while carrying the each backpack in an ambient climate of 20-25^0 C and 30-40% relative humidity while carrying each backpack. The backpack was adjusted for comfort immediately prior to the start of the treadmill walk. The subjects wore their own pants, shorts, T-shirt, socks and gym shoes.

Figure-1. Subjects were simulating a climbing trip using treadmill.

Experimental walks for each subject were undertaken on three different days from 09:00 until 13:00 using different backpacks. The distance between the first and subsequent retrieval of data is at least 3 days for each subject, with the aim of restoring the physical condition of the subjects. The experiment was conducted from December 2015 until March 2016.

e) Measurements

1) Surface EMG and ECG: Surface EMG serves to see the impact of backpack used to the subject's muscle. Based on preliminary survey results, the users often experience pain on the right shoulder after using backpack. Therefore, the right upper trapezius muscle was chosen to record the EMG signals when performed the task. The subjects' skin was prepared and cleaned for placing the electrode. Bipolar Ag/AgCl surface electrodes were placed with an inter electrode distance of 20 mm at the belly of the right upper trapezius muscle. Electrode positions were located according to Hermens *et al.* [12].

Furthermore, ECG was used to measure the electrical activity of the heart muscle that is useful to see the impact of backpack to the subjects' heart pressure or tension after simulating the climb. ECG leads are attached on the front of the chest. A small amount of gel is applied to the skin, which allows the electrical impulses of the heart to be more easily transmitted to the ECG leads.

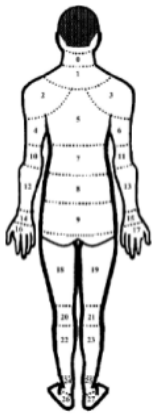
EMG and ECG measurements performed twice for each measurement day. Firstly it was conducted before the subjects bear the backpack and perform walk simulation. The second measurements were performed after simulated climbing for an hour. The measurements were taken while the subjects sitting on a chair in a relax position.

Figure-2. Measurements of EMG and ECG.

2) Perceived Musculoskeletal Discomfort: A modified Nordic Body Map questionnaire has been used to capture subject perceptions of musculoskeletal discomfort before and after task performance [13] and [14]. It is essential to know the relationship between the objective and subjective measures of musculoskeletal discomfort. It caused by people respond to the surroundings as they

perceive it rather than as it "really is" [15]. The advantage of using subjective measurements such as rating scales is that they are easy to administer and do not require any instrumentation or calibration. The process is generally non-invasive (although it may interrupt the task), and the data are easy to interpret [16].

3)



No	Location	Grade of complaints			
		A	B	C	D
0	Pain/stiff in the upper neck				
1	Pain in the lower neck				
2	Pain in the left shoulder				
3	Pain in the right shoulder				
4	Pain in the left upper arm				
5	Pain in the back				
6	Pain in the right upper arm				
7	Pain in the waist				
8	Pain in the buttock				
9	Pain in the bottom				
10	Pain in the left elbow				
11	Pain in the right elbow				
12	Pain in the left lower arm				
13	Pain in the right lower arm				
14	Pain in the left wrist				
15	Pain in the right wrist				
16	Pain in the left hand				
17	Pain in the right hand				
18	Pain in the left thigh				
19	Pain in the right thigh				
20	Pain in the left knee				
21	Pain in the right knee				
22	Pain in the left calf				
23	Pain in the right calf				
24	Pain in the left ankle				
25	Pain in the right ankle				
26	Pain in the left foot				
27	Pain in the right foot				

Figure-3. A modified nordic body map questionnaire. A (No pain = 1 point), B (Moderate pain = 2 point), C (Pain = 3 point), D (Very painful = 4 point) Source: [14].

These measurements were administered before and after an hour walk. The subjects were asked about their perceived muscular strain in the neck, shoulders, upper and lower back, elbows, wrists, hips, knees, ankles, etc. The administrations of the questions before and after the experiment were repeated in a balanced design for each backpack.

4) Data Analysis: Data derived from EMG and ECG measurements were processed and filtered using Cobra4 software from PHYWE System GmbH und Co.KG. The results, EMG and ECG amplitude, than were analysed statistically using the Microsoft Office Excel and Statistical Package for the Social Sciences (SPSS) for Windows version 20.0. Extreme outliers, results that are unreasonable and probably resulted from errors in measurement or recoding were carefully identified and eliminated. The data were tested for normality distribution before being used for further analysis using the Shapiro–Wilk test. It was found that the data was normally distributed. Descriptive statistics, including means and percentage of differences of the above measurements were calculated.

3. RESULTS

a) Surface EMG

Figure-4 presents the mean EMG amplitude before and after experiment for all types of backpack. The results show that the mean EMG amplitude of the right upper trapezius muscle increase after subjects conducting the experiment. It also specifies that percentages of EMG amplitude differences before and after the experiment were 27.17% for Pack X, 81.56% for Pack Y, and 87.67% for Pack Z. It indicates that the highest percentage of EMG amplitude differences is on Pack Z.

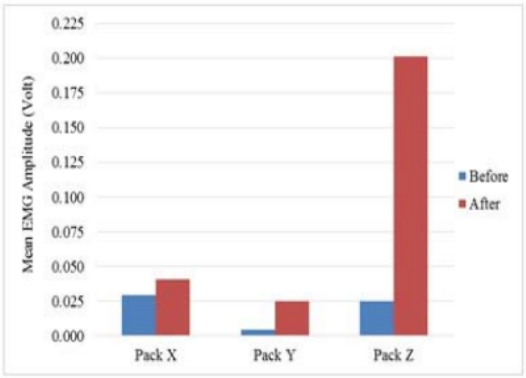


Figure-4. Mean EMG amplitude before and after experiment.

b) ECG

Figure-5 demonstrates the differences of mean ECG amplitude before and after experiment. The mean ECG amplitudes were higher after subjects conducting the experiment for all types of backpack. The differences of mean ECG amplitude were 8.22% for Pack X, 1.22% for Pack Y, and 52.28% for Pack Z. The results indicate that the largest discrepancy occurs when a subject using Pack Z for experiments.

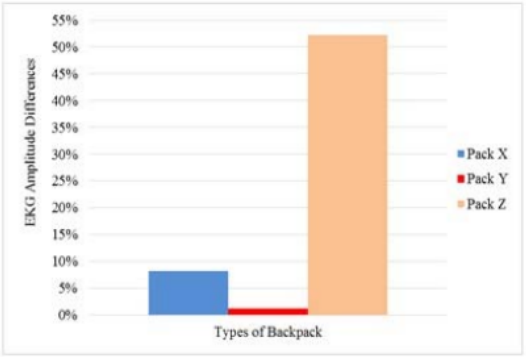


Figure-5. ECG amplitude differences.

c) Nordic body map questionnaire

Figure-6 illustrates the differences of musculoskeletal complaint scores for the five highest complaints for each backpack. The musculoskeletal complaints after experiment are higher than before experiment. Subjects felt more pain in the right and left shoulders after experiment using all types of backpack.

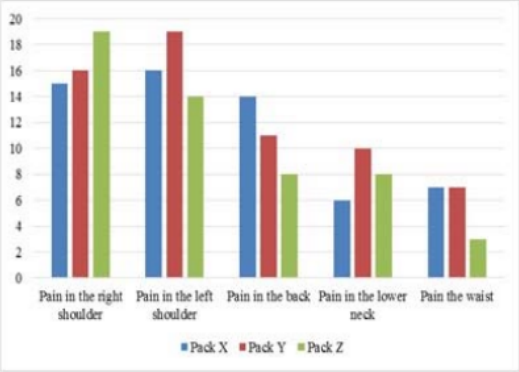


Figure-6. Nordic body map questionnaire score differences before and after experiment.

The highest difference of musculoskeletal complaint score in the right shoulder occurs when subjects use Pack Z (19 point). However, subjects experienced more pain in the left shoulder and the lower neck when they use the Pack Y (19 and 10 point, respectively), whereas for pain in the back was felt by subjects when using Pack X (14 point).

4. DISCUSSIONS

This study evaluated three types of mountaineering backpacks using physiological measurements (Surface EMG and ECG) and subjective measurement (Nordic Body Map questionnaire). The selection of backpacks used for experiment was based on preliminary studies conducted to investigate the frequently used backpacks in Indonesia, especially in Padang, West Sumatera.

The EMG data shows that mean EMG amplitude increased after conducting experiments. The increase in amplitude indicates that there has been occurred muscle fatigue on the measured muscle [17]-[19]. In addition, the results show that the highest increase in EMG amplitude occurs when subjects use Pack Z. This suggests that the use of Pack Z affects most to subjects' muscle fatigue. The reasons for this condition could be caused Pack Z do not have back adjustment system. It also has shoulder strap with soft foam but it is thin so if used for a long time, it can suppress the shoulder and cause pain. Pack Z also has no breathable back system causing heat feeling to the subjects.

Pack Y caused lower muscle fatigue than Pack Z. Pack Y also does not have back adjustment system, so that the subjects with extreme posture (Tall, short, slim, small or large), will feel a bit sore after a long time using the bag. Pack Y has a slightly thick foam strap so that respondents feel hot when using it. Air circulation was in the middle of backpack, but depressed and inhibited by back pad, so that the back cushion can be soaked in subjects' sweat. Pack Y is the heaviest bags compared to Pack X and Z. However, it has stronger material than Pack Z.

Muscle fatigue caused by use of Pack X is lower than use of Pack Y and Z. Pack X has back adjustment systems. It also has breathable back system so make the back is not hot or wet when used. Pack X also has a bearing backs like hollow body so that the users will feel more comfortable when use it. Pack X has a strong material, thick and soft pads.

Similar to the EMG results, the ECG data show that the highest electrical activity on heart muscle occurs when subjects using Pack Z, followed by Pack Y and X during experiments. This indicates that all backpacks causes fatigue among subjects, particularly in the Pack Z. This is due to Pack Z has a thin straps, so the subjects feeling pinched in the body near the armpit because of the backpack load. So that in a long use, subjects would feel pain and heavy. Pack X and Y also have thick and sturdy pad design and in accordance with the users' backs, so the backpack load does not suppress the body when use the packs.

Results from modified Nordic Body Map questionnaire demonstrated that subjects felt highest pain in the right shoulder, followed by in the back, neck, and waist. The reason for this issue might be that the subjects are all right handed. This muscle is located at the base of the neck, down towards the shoulder and arm, and passes under the shoulder blade. When this muscle shortens and tightens, it generates neck pain, usually caused by 'tension, stress, lack of exercise, poor ergonomics, or keeping a sitting posture for long time' [38]. These results were also consistent with other studies showing that the shoulder elevators are mainly sensitive to fatigue when performing tasks with the upper limb at or above shoulder level [21]-[23].

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AN ERGONOMIC EVALUATION OF MOUNTAINEERING BACKPACKS

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ABSTRACT

Backpack is one of the essential equipment that must be owned by a nature lover or a mountaineer when doing the adventurous activities. There are various types of backpacks on the market with a variety of brands, shapes and sizes according to the desires and needs. However, there are still complaints from the users when or after using those bags. Therefore, this study was conducted to analyse the backpack from the ergonomics side, specifically the influence of the use upon the body muscle and the heart muscle tension on three types of mountaineering backpacks that are often used namely Pack X, Y and Z. This study used Surface Electromyography (EMG) to analyse the muscle activity, Electrocardiography (ECG) to analyse the electrical activity of heart muscle, and Nordic Body Map (NBM) questionnaires to investigate the user perceptions of musculoskeletal discomfort. Twenty nature lover students were participated as the subject in the study. EMG and ECG data retrieval as well as filling out the NBM questionnaire performed before and after simulated trip for an hour using the treadmill in the laboratory by 20 subjects. The results indicated that Pack Z is less ergonomic than Pack X and Pack Y. The study also generates some criteria in choosing the ergonomic backpack based on analysis of muscle and heart electrical activities of the subjects.

Keywords: ergonomic, EMG, ECG, backpack, mountaineering.

1. INTRODUCTION

Adventurous activities, especially climbing or mountaineering, are becoming increasingly popular in Indonesia, especially for young nature lovers. Besides should have strong and healthy body physically and mentally, a mountaineer should also be equipped with convenient and safety equipment, one of them is backpack. This affects the development of mountaineering backpacks design. The design of current high-performance backpacks is very sophisticated with variety of features, sizes, and price. However, preliminary study results show that there are still many complaints from users after using those backpacks.

The preliminary study was conducted in Padang, West Sumatera, to 30 mountaineering backpack users through interviews. It was found that users frequently felt pain in some parts of their body after using the backpacks. The highest complaint perceived by the users is on the right shoulder (90%), on the left shoulder (83.33%), and on the waist (60%).

There is a large body of research addressing the evaluation of backpacks, most of them are backpacks for school children [1]-[4]. Many researchers had studied extensively about the physiological, biomechanical, and psychological effects of different types of backpacks [5]-[8]. Some previous researches also discussed the comparison of some different types of backpacks [9] and [10]. However, there is still lack study in evaluating mountaineering backpacks in terms of ergonomics and make comparison on some types of those backpacks.

A previous study by Retnari *et al*. [11] has been conducted to analysis the use of mountaineering backpack on female mountaineers. The study then designed the ergonomic mountaineering backpack for female mountaineers in Indonesia.

Therefore, this study conducted to evaluate three types of mountaineering backpacks mostly used in Padang, West Sumatera Indonesia in terms of ergonomics. The study also gives some recommendations for choosing or designing ergonomics mountaineering backpacks.

2. MATERIALS AND METHODS

a) Subjects

Twenty nature lover students from University of Andalas, Padang, West Sumatera, Indonesia (10 male and 10 female) participated in the study. All subjects were informed the procedures of the experiment and gave their informed consent to participate in the study. The subjects were healthy and had no acute back or neck complaints which would influence their performance adversely. Their mean (SD) physical characteristics were: age 21.60 (1.82) years, stature 1.64 (0.08) m, body weight 55.65 (9.39) kg.

b) Backpacks

Table-1. Backpack features.

No.	Features	Type		
		X	Y	Z
1	Weight	2,95 kg	5 kg	2,50 kg
2	Height adjustable lid closure	√	√	√
3	Back adjustment system	√	-	-
4	Well-padded shoulder strap	√	√	√
5	Sternum strap	√	√	√
6	Well-padded waist strap	√	√	√
7	Breathable back system	√	√	-
8	Internal contoured frame design	√	√	√
9	Material	*Duratex*	*Cordura 500D, Cordura 1000D*	*Full Cordura*

Three high-performance and internationally renowned mountaineering backpacks with 60 litre average volume were used. Pack X was manufactured in Germany, while Pack Y and Z were manufactured in Indonesia. The features of each backpack were presented shown concluded in Table-1. Those backpacks were chosen because they were the most likely to be used by the respondents in Padang, West Sumatera, Indonesia.

c) Instrumentations

Cobra 4 Sensor-Unit Electrophysiology: Electrocardiography (ECG) and Electromyography (EMG) System complete with disposable surface electrodes Ag/AgCl/Solid adhesive pre-gelled were used to record the electrical activity of heart and muscle. Data obtained was then analyzed using Cobra4 software from PHYWE System GmbH and Co.KG.

d) Experimental design

Each subject simulated a climbing trip with walked for an hour on a treadmill at 3 km per hour with various tilt angles. The experiment was carried out in Laboratory of Work System Design and Ergonomics, Department of Industrial Engineering, University of Andalas, Padang, West Sumatera, Indonesia. In the first 10-minute, the walk was conducted at the angle of 0^0, then, in the second 10-minute, the walk was conducted at the angle of 4^0. The third 10-minute, the walk was conducted at the angle of 8^0, and 30 minutes later, the walk was conducted at the angle of 10^0. The subjects were measured while carrying the each backpack in an ambient climate of 20-25^0 C and 30-40% relative humidity while carrying each backpack. The backpack was adjusted for comfort immediately prior to the start of the treadmill walk. The subjects wore their own pants, shorts, T-shirt, socks and gym shoes.

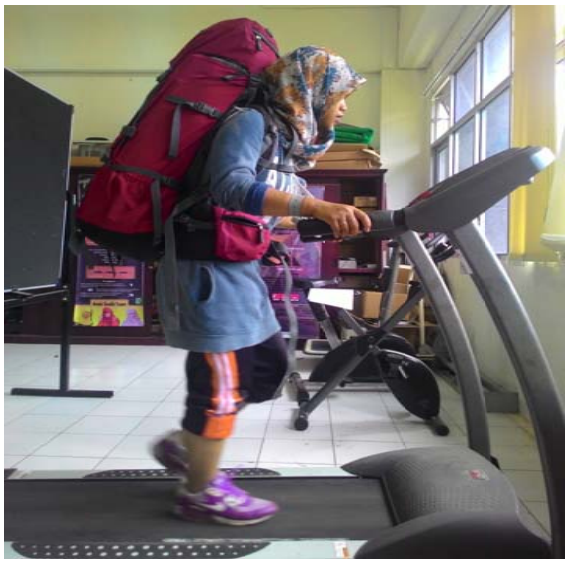


Figure-1. Subjects were simulating a climbing trip using treadmill.

Experimental walks for each subject were undertaken on three different days from 09:00 until 13:00 using different backpacks. The distance between the first and subsequent retrieval of data is at least 3 days for each subject, with the aim of restoring the physical condition of the subjects. The experiment was conducted from December 2015 until March 2016.

e) Measurements

1) Surface EMG and ECG: Surface EMG serves to see the impact of backpack used to the subject's muscle. Based on preliminary survey results, the users often experience pain on the right shoulder after using backpack. Therefore, the right upper trapezius muscle was chosen to record the EMG signals when performed the task. The subjects' skin was prepared and cleaned for placing the electrode. Bipolar Ag/AgCl surface electrodes were placed with an inter electrode distance of 20 mm at the belly of the right upper trapezius muscle. Electrode positions were located according to Hermens *et al.* [12].

Furthermore, ECG was used to measure the electrical activity of the heart muscle that is useful to see the impact of backpack to the subjects' heart pressure or tension after simulating the climb. ECG leads are attached on the front of the chest. A small amount of gel is applied to the skin, which allows the electrical impulses of the heart to be more easily transmitted to the ECG leads.

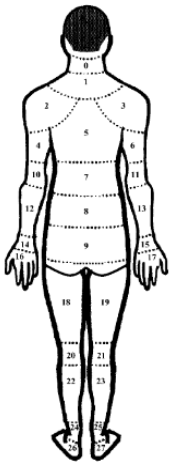
EMG and ECG measurements performed twice for each measurement day. Firstly it was conducted before the subjects bear the backpack and perform walk simulation. The second measurements were performed after simulated climbing for an hour. The measurements were taken while the subjects sitting on a chair in a relax position.

Figure-2. Measurements of EMG and ECG.

2) Perceived Musculoskeletal Discomfort: A modified Nordic Body Map questionnaire has been used to capture subject perceptions of musculoskeletal discomfort before and after task performance [13] and [14]. It is essential to know the relationship between the objective and subjective measures of musculoskeletal discomfort. It caused by people respond to the surroundings as they

perceive it rather than as it "really is" [15]. The advantage of using subjective measurements such as rating scales is that they are easy to administer and do not require any instrumentation or calibration. The process is generally non-invasive (although it may interrupt the task), and the data are easy to interpret [16].

3)



No	Location	Grade of complaints			
0	Pain/stiff in the upper neck	A	B	C	D
1	Pain in the lower neck				
2	Pain in the left shoulder				
3	Pain in the right shoulder				
4	Pain in the left upper arm				
5	Pain in the back				
6	Pain in the right upper arm				
7	Pain in the waist				
8	Pain in the buttock				
9	Pain in the bottom				
10	Pain in the left elbow				
11	Pain in the right elbow				
12	Pain in the left lower arm				
13	Pain in the right lower arm				
14	Pain in the left wrist				
15	Pain in the right wrist				
16	Pain in the left hand				
17	Pain in the right hand				
18	Pain in the left thigh				
19	Pain in the right thigh				
20	Pain in the left knee				
21	Pain in the right knee				
22	Pain in the left calf				
23	Pain in the right calf				
24	Pain in the left ankle				
25	Pain in the right ankle				
26	Pain in the left foot				
27	Pain in the right foot				

Figure-3. A modified nordic body map questionnaire. A (No pain = 1 point), B (Moderate pain = 2 point), C (Pain = 3 point), D (Very painful = 4 point) Source: [14].

These measurements were administered before and after an hour walk. The subjects were asked about their perceived muscular strain in the neck, shoulders, upper and lower back, elbows, wrists, hips, knees, ankles, etc. The administrations of the questions before and after the experiment were repeated in a balanced design for each backpack.

4) Data Analysis: Data derived from EMG and ECG measurements were processed and filtered using Cobra4 software from PHYWE System GmbH und Co.KG. The results, EMG and ECG amplitude, than were analysed statistically using the Microsoft Office Excel and Statistical Package for the Social Sciences (SPSS) for Windows version 20.0. Extreme outliers, results that are unreasonable and probably resulted from errors in measurement or recoding were carefully identified and eliminated. The data were tested for normality distribution before being used for further analysis using the Shapiro–Wilk test. It was found that the data was normally distributed. Descriptive statistics, including means and percentage of differences of the above measurements were calculated.

3. RESULTS

a) Surface EMG

Figure-4 presents the mean EMG amplitude before and after experiment for all types of backpack. The results show that the mean EMG amplitude of the right upper trapezius muscle increase after subjects conducting the experiment. It also specifies that percentages of EMG amplitude differences before and after the experiment were 27.17% for Pack X, 81.56% for Pack Y, and 87.67% for Pack Z. It indicates that the highest percentage of EMG amplitude differences is on Pack Z.

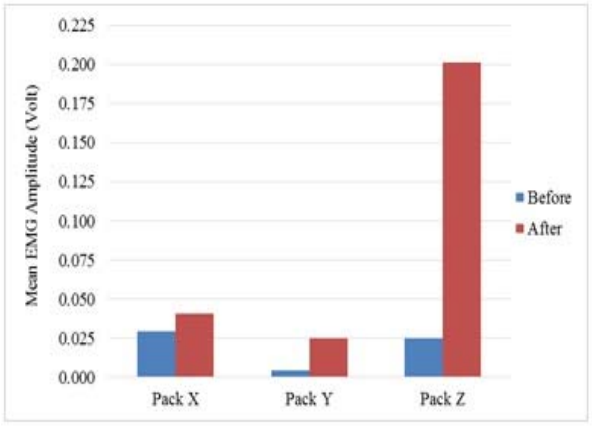
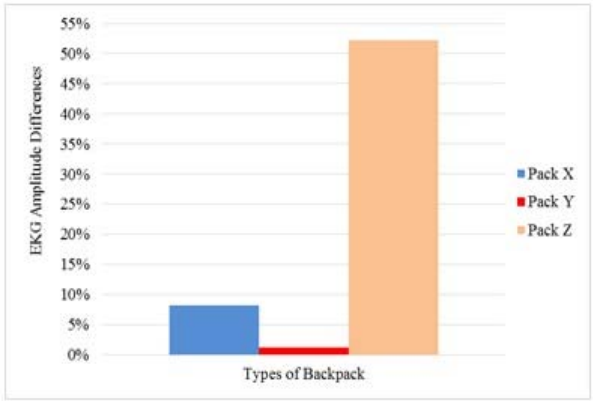


Figure-4. Mean EMG amplitude before and after experiment.

b) ECG

Figure-5 demonstrates the differences of mean ECG amplitude before and after experiment. The mean ECG amplitudes were higher after subjects conducting the experiment for all types of backpack. The differences of mean ECG amplitude were 8.22% for Pack X, 1.22% for Pack Y, and 52.28% for Pack Z. The results indicate that the largest discrepancy occurs when a subject using Pack Z for experiments.



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c) Nordic body map questionnaire

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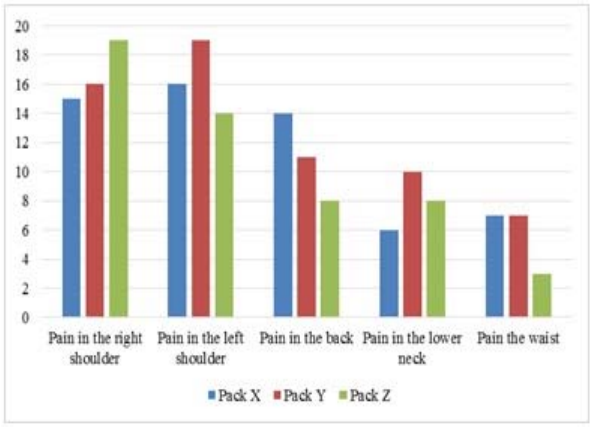

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5. CONCLUSIONS

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LEMBAR
HASIL PENILAIAN SEJAWAT SEBIDANG ATAU PEER REVIEW
KARYA ILMIAH : JURNAL ILMIAH*

Judul Karya Ilmiah (Artikel) : **An Ergonomic Evaluation of Mountaineering Backpacks**

Jumlah Penulis : 4 Orang

Status Pengusul : Penulis Ke-2

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c.	Kecukupan dan kemutahiran data/informasi dan metodologi (30%)	12				12
d.	Kelengkapan unsur dan kualitas penerbit (30%)	12				10
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