

# The Participatory Ergonomics As A Basis Of Sports Facilities Redesign In Reducing The Fatigue Of The Court Workers And The Setup Time Of Tennis Net

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**Abstract**— Sports facilities are usually redesigned by considering its functions, but not for the users' interests and needs yet, as there are still some problems found in the setup activities of sports facilities such as unstable processing time, overuse of muscles, unnatural working posture and tendency of ineffective working movement. The movement of moving the sports facilities from any place to another is conducted by the appointed people. Since this work is conducted repeatedly, there are some problems on workload and finishing time of the works occurred that is considered as the usual matter. The purpose of this research is to find out the the most dominant aspects of decrease of fatigue on working in order to improve the future work. It is an experimental research with treatment by subject design. It was conducted directly and by recording the working movements in accomplishing the setup of tennis net. It was analyzed statistically by conducting by previously conducting the data normality test by using shapiro wilk with a significance level  $\alpha=0.05$ . The results showed that there was a decrease on the fatigue of the court workers in conducting the setup of tennis net based on the redesign of sports facilities. The general decrease on fatigue is 14.99%. The decrease on fatigue based on the order from the highest aspects of fatigue is motivation 19.13%, activity fatigue 12.29%, and physical fatigue 10.44%. The decrease on setup time is caused by the adaptation to the new working organization. The average of decrease on cycle of the setup cycle of the biggest net is on the transportation from the stairs to the location or court, that is  $30.6 \pm 8.91$  seconds. The design of sports facilities with a participatory ergonomics approach is able to compile, to identify, and to decide the priority of problem resolve so that the design is suited to the needs and desire of the users

**Index Terms**— Participatory, Ergonomics, Sports facilities, Tennis

## 1 INTRODUCTION

Every working activity requires planning and calculating of the right time to obtain an optimal work output. The planning of the needs of time has an impact on the length of the completion of any work activity. The installation of net requires accuracy and speed in time for the purpose of the game of any sport. If the setup time is not done quickly, it will result in the postponed game. A preparation in which does not consider a minimum time, can result in the absence of working patterns, whereas this setup activity is usually conducted by muscle power of the humans. Until now, there are no measurable working Organization and Standard Time founded yet to complete the setup activity of sports facilities.

In general, every human being needs a sport activity to maintain endurance and health conditions. Sport is an activity that is open for everyone according to his/her ability and interest [16]. Sport for all was developed for the first time by the European people in 1960 [5]. The movement of sport for all was pioneered in the 1980s in Indonesia [10]. As the developing era, there are varied kinds of sports that are influenced by socio-cultural, economic, geographic and political conditions ([16]. The development of various kinds of sports is always followed by the provision of sports facilities that are more complex as well. The costs for purchasing the expensive sports

facilities [6] require strict maintenance procedures, from the maintenance until the storage procedures as well as the sports facilities for Tennis.

The complex facilities in every sport require the expert setup officers, but there are some facilities of different sports that can be used in turn in the same place or court, such as sepak takraw, badminton and Tennis [14], that have differences on its own lines and the height its own nets. These differences affect the officers of the pithc in the setup to prepare the suitability of the game.

These complex sports facilities are strongly associated with the development of technology [16]. The approach to the design of sports facilities can not be separated from the demands. In order to get an optimal benefit from the sports facilities, the design should consider the purpose of the game and dynamic anthropometric of the users so that those can be utilized optimally by the users. In other words, the design of sports facilities from several countries may also differ, especially for the design of sports facilities of which purpose is to maintain fitness or physical health. Due to the size of body anthropometry in a country to another country may differ, the design of the facilities is also differ, as the opinion [24] that there are differences in the data of body dimensions or characteristics of anthropometry of the Chinese, Japanese, Korean, and Taiwanese people.

Participatory ergonomics is an activity of working facility improvement that considers the desire and needs of the users, so that they feel that the facilities are created based on the conditions that accommodate the needs and requirements

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while playing in the court. The ideas and notions from the users are identified and selected for the priority of problem resolve. The concept of participatory ergonomics is human empowerment or to humanize human, involving all users and policy makers for the improvement of work. Participatory ergonomics is a realization of the implementation of ergonomic balancing.

Sports facilities, especially for Tonis, are prepared by a special court officer. The activities of the officer at the setup time do not have natural body movements, in which overload lifting exceeds the maximum limit, frequent muscle injury, the different setup time between the first and the following period. Fatigue begins from muscle fatigue, so that he/she needs to restore the muscle tension [2]. The fatigue results in the decreased immunity and concentration [13] as well as musculo-skeletal complaints arise in a certain part of body muscles [18].

On the net installation setup for Tonis, the body movements during the process of installing and installing the net are ineffective and repeating, so that affect the time of completion of the work and result in premature fatigue. Until now, fatigue has not been defined yet but can be felt. However, fatigue can be traced with the help of 30 questions concerning the fatigue given to the court workers before and after the activities.

## 2 METHODS

### 2.1 Subject

Subject in this research is the court workers with tasks or activities to setup the sports facilities such as moving and installing the Net for the preparation of Tonnis. In detail, the activities of workers are as follows: a) Moving the sports facilities from the warehouse to the stairs, b) Moving the sports facilities from the stairs to the location or court, c) Assembling the net until it stands perfectly and is ready to use.

### 2.2 Procedure of the Research

It is an experimental research with the treatment by subject design. In this research, there were direct observation and recording of the movements of the court workers in completing the setup process of net installation for Tonnis. Recording the work postures by video  $f = 2,9$  to 116 mm, with the result of 1: 1,8, 40 X optical zoom. The recordings from some of the cycle time (WS) were then selected for the stable movements or study state, played in slow motion, and the images identification based on the working movements element on 14 therbligh movements. The images were processed using Adobe Premiere program.

### 2.2 Procedure of the Analysis

The statistical analysis was conducted by using SPSS Version 17 Software. There was a paired sampe test conducted by previously conducting the data normality test using a Shapiro wilk test with a significance level of  $\alpha=0,05$ . Comparing the time differences of installing the net until it stands per-

fectly using the old way and new way or after the redesign of the net poles. The comparability and treatment effect tests were conducted to find out the differences of the averages and standard deviations as well as the significance level.

## 3 RESULT AND DISCUSSION

The participatory ergonomics approach has some impacts on the volume of feedback, ideas or notions from the user, so this approach provides a place to accommodate the problems and alternative solutions to the problems that really exist in the court. Participatory ergonomics does not need a high cost, because the process is empowering the court workers to do the installation of the net that has been done on a daily basis and becomes their main duty. In general, in order to explore, identify and reveal the problems, it needs an analysis approach from the study of ergonomics or often known as participatory ergonomics [19].

Since the compiled problems are the daily problems and are always faced by, the the suggestions about the improvement are also not far from the desires or expectations of the workers. All this time, the net pole is only designed based on its functions, without any consideration for the ease of handling and of transportation, as well as of maintenance and the optimal utilization for other supporting functions. The net pole design that is based on the mechanism of participatory ergonomics, results in a new draft of net pole (Figure 2), that has 4 wheels at the bottom functioning to ease the transportation and moving of the sports facilities. On the front side, the wheels are equipped with fasteners so that when the net is stretched the wheels can be fastened tightly. By equipping the wheels with fasteners, and that it can be operated manually using the workers' feet, the workers do not need to do an excessive bending movement. The Net poles are placed on the sides. The purpose of this installation is that it has a possibility to place a drinking water container in the middle of the pole for the players' needs. The redesign of the net pole with the addition of water needs is designed based on the ideas or notions from the workers and players, so that the expected desires and needs of all parties can be realized in the form of a new product design (Figure 2).



Figure, 1. Old Net Pole



Figure 2. New Net Pole

The design that prioritizes on the easiness and convenience in operating a tool has some impact on the setup speed on net installation. The facilities that are designed using the anthropometric data approach, as according [4] state that the anthropometric measurements become the basis for product design in order to have no negative effect on the health of workers. According [11] state that it is designed with anthropometric data and user center design gives users the advantage of the increased fitness. Reinforced by the results of a research [12] that anthropometric measurements can be used for a design of an ergonomic work station, for personal protection equipments, and for comfortable, productive, user-friendly equipments and facilities.

The impact of the net pole design provides convenience in the setup process of the net, and can also decrease subjective complaints from the workers, as the opinion [17] that subjective complaints due to their less-natural working postures, while according [7] state that work with facilities that are not ergonomic cause the excessive fatigue.

Time spent used on the activity of the of new and old net setup is recorded using a Video recorder. There was a decrease in the time of completion of work activities using the new ways. This condition occurs due to the improvement on working organization. The improvement on working organization decreases the postural stress of the body so that it works naturally [21]. This decrease occurs due to the improved working organization, that the other impact is the decrease in the duration of the completion of the work. The time differences on the transportation from the warehouse to the stairs (transportation 1), from the stairs to court location (transportation 2) and net assembly time until it is ready for Tonis games are presented in Table 1.

**TABLE 1. THE TIME DIFFERENCES OF NEW AND OLD SETUP CYCLES**

Warehouse – Stairs (seconds)	Stairs – Location (seconds)	Net Assembly (seconds)
-16	-10	-3
-31	-27	-10
-19	-41	-13
-18	-40	-12
-20	-22	-12
-19	-21	-23
-10	-23	-22
-22	-23	-31
-21	-27	-28
-12	-35	-25
-31	-40	-22
-28	-42	-24
-41	-45	-18
-27	-25	-8
-20	-38	-16

Based on Table 1, it can be seen that overall, the time

decrease are marked by a negative value between the old way and new way. The average of the decrease in time of net setup cycle from transport (1) is  $-22,33 \pm 6,18$  seconds, transportation (2) is  $-30,6 \pm 8,91$  seconds, transportation (3) is  $-17,8 \pm 6,75$  seconds. The biggest decrease is in transportation from the stairs to the location. Transportation (2) is using the manual-handling, both hands carry the load of the net facility that will be assembled. The limitation of workers with only their two hands gives the option to hold and carry the equipments in turn or can not be conducted simultaneously. This condition has been improved with a new sports facilities design using the concept of participatory ergonomics. The workers can carry the facilities simultaneously by maximizing their grip in carrying the facilities simultaneously while considering the maximum load. The heavy facilities that are not necessary to lift are only dragged in which will decrease the muscle strength. In the new way, there are some ease in transportation, and workers' movements improvement. The movements of both hands are more effective, that decrease the ineffective movements. The decrease in time for searching and selecting, and decrease in movements with maximum arm reach, orderly, there is also a decrease in body movements for squatting and bending. The body activities in the form of squatting and bending are still occurred based on the video recording, but decreased in the intensity and frequency of movements.

The measurement of subjective feelings of fatigue was conducted by using a questionnaire developed by the Subjective Self Rating Test from the Industrial Fatigue Research Committee (IFRC) Japan (Tarwaka, 2010), contains 30 items of rating scale in which consist of three categories; weakened working activities (items 1-10), decreased motivation (items 11-12), physical exhaustion (items 21-30) (Yoshitake, 1971). Fatigue is a condition in which there are decreased endurance [3], decreased performance [8], [9], workers can not receive the workload [15]. The scores of operator's fatigue in the setup and installation of a new-way net and the old net will be completely presented in Table 2.

**TABLE 2. THE SCORES OF OPERATOR'S FATIGUE IN THE SETUP AND INSTALLATION OF A NEW-WAY NET AND OLD NET**

Parameter	Improvement	Average	SD
General Fatigue	Old way	75.07	2.80
	New way	63.82	1.22
Activity Fatigue	Old way	24.41	1.78
	New way	21.41	0.76
Motivational Fatigue	Old way	25.61	1.19
	New way	20.71	0.65
Physical Fatigue	Old way	24.82	1.44
	New way	22.23	1.12

Fatigue is divided into two, namely the physical fatigue that arises due to physiological changes and mental fa-

tigue that is seen in a state of mental instability or often known as pseudo-fatigue [1]. In this study, fatigue is classified into general fatigue, activity fatigue, motivational fatigue and physical fatigue. According [20] the results of fatigue analysis can be used as the basis of physiological improvement recommendation. The differences on scores of the fatigue of the old-way workers is on the working organization by setting up the net in old way and the new-way net setup by using the new-way working organization that is caused by the adjustment on the net design that can be seen in detail in Table 3.

**TABLE 3. THE DIFFERENCES ON THE SCORES OF OLD-WAY AND NEW-WAY WORKERS' FATIGUE**

Parameter	Improvement	Average	SD
General Fatigue	Old way	75.07	2.80
	New way	63.82	1.22
Activity Fatigue	Old way	24.41	1.78
	New way	21.41	0.76
Motivational Fatigue	Old way	25.61	1.19
	New way	20.71	0.65
Physical Fatigue	Old way	24.82	1.44
	New way	22.23	1.12

Based on Table 3, the average of general fatigue, activity fatigue, motivational fatigue, and physical fatigue overall have a decrease. This condition is caused by the workers who had implemented the principle of economical movements. The reinforcement of the scores of fatigue before and after Net installation by using the old way and new way is shown in Table 4.

**TABLE 4. THE RESULTS OF STATISTIC ANALYSIS OF THE FATIGUE SCORES BEFORE AND AFTER NET INSTALLATION**

Variable	Average		Decrease (%)	t	Sig. (2-tailed)
	Old way	New Way			
General Fatigue	75.07	63.82	14,99	4.774	0.000
Activity Fatigue	24.41	21.41	12,29	10.070	0.000
Motivational Fatigue	25.61	20.71	19,13	4.559	0.001
Physical Fatigue	24.82	22.23	10,44	9.224	0.000

Based on Table 4, the results show that the average of general fatigue, activity fatigue, motivational fatigue and physical fatigue overall have a significant change, or  $p < 0,05$ , means that there are some differences between the scores of fatigue before and after working activities. The scores of activity fatigue on the new net setup is lower than of old net setup. The court workers' general fatigue decreases by 14.99%,

while the activity fatigue by 12.29%. This condition is caused by the monotonous activities, so that the lowest decreases in fatigue scores compared to the other aspects are the motivational fatigue of 19.13% and physical fatigue of 10.44%. The differences on the motivational fatigue have the highest scores due to the decreased motivaton of the court workers, it is possible becaause the reciprocity between tasks and demands of the work are not yet balanced, working reluctantly because it spends more energy at the time of the transportation of sports facilities. Irregular work organization makes the motivational fatigue becomes the most dominant attention.

#### 4 CONCLUSION

There was a decrease on fatigue of the court workers in a new net setup as a result of the design. The new net design uses a participatory ergonomics approach that is able to provide a more ergonomic design since it considers not only the function of the product, but also the needs and desire of the users that can be realized in the form of a new design of sports facilities. The decrease in general fatigue is 14.99%. The highest decreases in the motivational fatigue is 19.13%, activity fatigue is 12.29% and physical fatigue is 10.44%. There was a decrease in a new-way setup time that is due to the adjustment on the new design of the facilities. The largest average of the decrease in the setup cycle time of the net is on the transportation activities from the stairs to the location since the workers can carry the goods simultaneously, the heavy sports facilities is not necessary to be lifted using the full muscles of the workers, but only by dragging. There was an improvement on working movements in the form of a decrease in ineffective working movements

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