Testing Usability of Syringe Adapters and Conventional Syringe in Healthcare Workers

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Abstract

The increased use of syringes by health workers worries health workers because they can cause musculoskeletal disorders due to work. Hospitals, health centers, laboratories often use syringes to administer drugs to patients, make formulas or for drawing blood. The increased use of syringes by health workers motivated this research to develop and test a prototype of a syringe adapter. The aim of this research is that the prototype of a syringe adapter with usability testing can make it easier for health workers to use syringes, can minimize fatigue and muscle tension that occurs from conventional syringes, so as to minimize musculoskeletal disorders due to repeated use of syringes. Health workers play a major role in usability testing, because health workers directly test the prototype by usability testing and using an electromyogram. Usability testing was carried out on 20 nurses who frequently used syringes. The results in this study indicate that the use of the prototype muscle syringe adapter is smaller than the use of conventional syringes, so that it can significantly reduce musculoskeletal disorders in health workers.

Keywords
Healthcare workers, ergonomic tools, usability testing, musculoskeletal disorders, electromyogram

1. Introduction
The use of syringe activity in hospitals, clinics and laboratories is almost always used by healthcare workers (Ulbrich et al. 2020). Healthcare workers who use syringes repeatedly have an increased risk of musculoskeletal disorders (MacDonald and Keir, 2018). Musculoskeletal disorders that occur due to work have been shown to be more severe than injuries or other diseases. Musculoskeletal disorders also require longer recovery times than occupational injuries or illnesses (Gallagher and Heberger, 2013). Doctors, nurses, pharmaceutical technicians and laboratory service technicians often perform work using syringes. Repeated use of syringes is to take medicinal fluids and give medicines to patients (Ulbrich et al. 2020).

Repeated use of syringes, lack of rest in doing work activities and awkward hand posture include risk factors for musculoskeletal disorders (MacDonald and Keir, 2018). Nurses, doctors, laboratory technicians in chemotherapy treatment centers, mix and administer medicines to patients regularly for a long time. Such activities result in an increased risk of muscle tension occurring in healthcare workers. To give the medicines to chemotherapy patients, medical personnel manually give injections for up to 30 minutes and ensure the flow of infusions that work at 1-2 ml per minute is smooth. A study found that the upper extremities of chemotherapy health nurses have work-related musculoskeletal disorders due to repeated use of syringes (MacDonald and Keir, 2018). Syringes require high strength. These forces are combined with awkward posture, less hand rest and it can increase the risk of work-related musculoskeletal disorders (Hansson et al. 2009).

To reduce the risk of musculoskeletal disorders, it can use a prototype syringe adapter designed to minimize excessive muscle use. The problem today is that there are an average of 40 patients who will undergo the injection process of the patient performed on average 3 times a day. Nurses prepare to take medicines for 40 patients first, after all the medicines are prepared then the nurse gives the medicine to all those patients. The injection process from preparation to completion of the injection takes an average of 40 minutes. From this case the nurse performs repeated movements for the administration of the drug to the patient. Repetitive activities and carried out for a long time associated with the use of syringes, can result in musculoskeletal disorders for health workers. The quality of the syringe adapter prototype product is very important to be tested, because until now there has been no usability testing of the syringe adapter prototype for healthcare workers. In this study, chose usability testing because on usability testing, nurses directly tested prototypes to see the ability to perform drug withdrawal and expenditure as well as directly compare with the use of conventional syringes. Furthermore, after the nurse tested the prototype syringe adapter, in the test the nurse's usability directly assessed the quality and other aspects with a usability questionnaire. Therefore, in this study we chose the method of testing usability. In terms of product quality, among others, it must have features that function properly in accordance with its purpose, can be run or used easily by its users, and can make it easier for users to operate syringe adapter prototype anywhere and anytime. One aspect that is considered important for the quality of a product is usability. Usability is an aspect that measures how easily users can learn and use products to achieve their goals and the level of user satisfaction with them. This aspect can also give an idea of whether the syringe adapter prototype is suitable and preferred by its users or not (Dumas and Redish, 1999).

There are four methods to test usability, namely by model/metric based, inspection, testing and inquiry (Zaphiris and Kurniawan, 2007). The nielsen attribute of the usability method is classified in the testing method because, in this method, observing the user when interacting with the prototype is collecting and analyzing data to identify the problem. The nielsen attribute of usability method was used in this study as a proof of how usable the syringe adapter prototype was tested and as a factor of user satisfaction regarding the syringe adapter prototype as a whole. With the innovation of syringe adapter prototype and as technology advances, to be able to provide products that provide ease for healthcare workers in using syringes, this research was conducted to test the quality of syringe adapter prototype on the aspect of usability with the novelty in this study is that the syringe adapter prototype with usability testing can minimize muscle tension, fatigue and ease of use of the prototype by healthcare workers.

1.1 Objectives

This study aims to obtain the results of usability testing of syringe adapter prototypes using nielsen attributes of usability questionnaire based on Nielsen model and get the results of muscle activity comparison from electromyogram and average time required to fill prototype syringe adapter and conventional syringe. Thus, the output of this study is the development of prototype syringe adapters can reduce tension, fatigue and musculoskeletal disorders for health workers indicated by the comparison of the use of muscle activity prototype syringe adapters and conventional syringes.

2. Literature Review

The literature review in this study has the concept of "musculoskeletal disorders", "the development of syringes" and "the use of syringes". Literature review is very helpful in conducting research, understanding methodology, research steps, current research position and knowing the novelty of research.

The development of a standard syringe for the injection process using a syringe adapter was first carried out by Robinson et al. (2000). The design is optimized for comfort and convenience during injection with the syringe adapter used in amniocentesis. In this study, we compared two syringes with a volume of 20 mL, one with a syringe adapter and the other using a standard syringe. The results showed that the use of an adapter was indicated by the results of the experiment the resulting time was 32.4 seconds (24 - 45 seconds) with a standard syringe and 25.3 seconds (24 - 30 seconds) using a syringe adapter. Lin and Chen (2009) conventional syringes used by laboratory staff to dispense the right amount of fluid, resulting in prolonged repetitive movements during the working day resulting in discomfort in the upper extremities. EMG electrodes are placed on the forearm when using syringes and pipettes to identify factors that affect thumb strength and muscle load. The results of this study showed that the size of the syringe had a significant effect on the abductor muscle of the pollicis brevis and strong repetition was a significant risk factor for cumulative trauma disorders.

Sheikhzadeh et al. (2012) compared the preference and strength of injection using a conventional syringe and a new ergonomically designed syringe, in this study twenty-three Rheumatoid Arthritis (RA) patients were involved in this study. Finneran and O'Sullivan (2013) explained the effect of wrist posture, style and type of grip on the operator's muscle activity, endurance and task performance. Two wrist flexors and two extensors were recorded using electromyography during isometric application for each of the three types of grip in two wrist postures (neutral and flexible). Gallagher and Heberger (2013) investigate the interaction of force and repetition with the risk of musculoskeletal disorders (MSD) in order to determine the role of force and repetition in musculoskeletal tissue fatigue. The research was chosen as the subject of a methodological quality assessment and critical review. The study also looked at laboratory studies of fatigue failure to see how strength and repeat tissue failure responded. That there may be a relationship between force and repetition in terms of the risk of musculoskeletal disorders. Repetition appears to result in a small increase in risk for low-power tasks but a significant increase in risk for high-level tasks. Occhionero et al. (2014) investigated upper extremity musculoskeletal disorders in various groups of healthcare workers. The neck is the most frequently affected segment in dentists, with prevalence up to 73 percent and above 50 percent in 7 of 12 studies. In most studies, the hand/wrist has the highest prevalence in dental hygienists and laboratory technicians with risks including repetitive motion and restricted posture.

Nimunkar et al. (2017) measured the force of syringe withdrawal that worked systematically by varying the size of the syringe tube, needle size and viscosity performed by laboratory officers for the use of syringes in rats. Commercial laboratory technicians can perform as many as 200 to 500 mice per day so that they experience repetitive activities and can result in a risk of musculoskeletal disorders. The results showed the forces that occurred ranged from 3.5 to 28 N in repeated syringe use activities. MacDonald et al. (2017) conducted research on lengthy grip and suppression during syringe use in the activities of nurses, doctors, pharmacists, and other jobs that require mixing drugs or fluids. MacDonald and Keir (2018) examined the use of syringes by medical personnel in chemotherapy. The results showed that most of the working days performed for hand activities were 87% for pharmaceutical assistants and 72% for nurses. The study also suggested that there was a need to evaluate and redesign manual syringes and mix chemotherapy drugs to prevent musculoskeletal disorders in hospital staff.

Ulbrich et al. (2020) conducted research on developing and testing new syringe adapters designed to reduce musculoskeletal disorders associated with repeated fluid withdrawal. Three methods of syringe extension are using the ring finger, middle finger, and syringe adapter tested. The muscle tension that occurs is measured using an electromyogram. The result of this study is the development of the design of the syringe adapter when doing repetitive work using one hand significantly reduces the muscle tension that occurs. Although it takes a long time when using the adapter, the syringe adapter can reduce the occurrence of muscle tension. Therefore, this study will be conducted to develop, compare and test the prototype syringe adapter by reducing muscle tension and fatigue caused by repeated work by healthcare workers. In addition, the prototype syringe adapter uses an electronics system that makes it easier for healthcare workers to use or operate it.

3. Methods

3.1 Design Proses

The formulation of the problem is based on what output will be achieved in this study. The issue that will be discussed further is how the test results usability prototype syringe adapter for healthcare workers. The results of comparison of conventional syringes and prototype syringe adapters by healthcare workers. The objectives to be achieved in this study are: obtaining usability test results of syringe adapter prototypes using questionnaires nielsen attribute of usability based on the Nielsen model, and obtaining comparison results from electromyogram and the average time from a prototype syringe adapter and a conventional syringe.

The process of designing a prototype syringe adapter using Polylactic acid or thermoplastic polyester printed using 3D printing. A thermoplastic polyester made from a strong and durable material. The prototype syringe adapter is made with minimal weight in the hand to reduce the load on the hand. Figure 1 shows the syringe adapter configuration. Syringes in 3 mL, 5 mL, and 10 mL volumes can be used with the prototype syringe adapter. Figure 1 depicts a 5mL syringe labeled number 1. To reduce the weight of the prototype, an Arduino device is used, which can be seen in number 10 separately from the prototype. The prototype syringe adapter is a device that allows traditional syringes to be used for drug extraction (aspiration) and administration (injection). Using the Arduino system, healthcare workers will be able to run prototypes faster and with less stress on their working muscles. On the Arduino system box there is an LCD screen and four buttons (up, down, enter, and on/off) for selecting the function menu on the Arduino electronic device shown in number 10. A button (start/stop) is available in the prototype to start aspiration and to injection drug delivery shown in number 5. All units in Figure 1 are in millimeters.

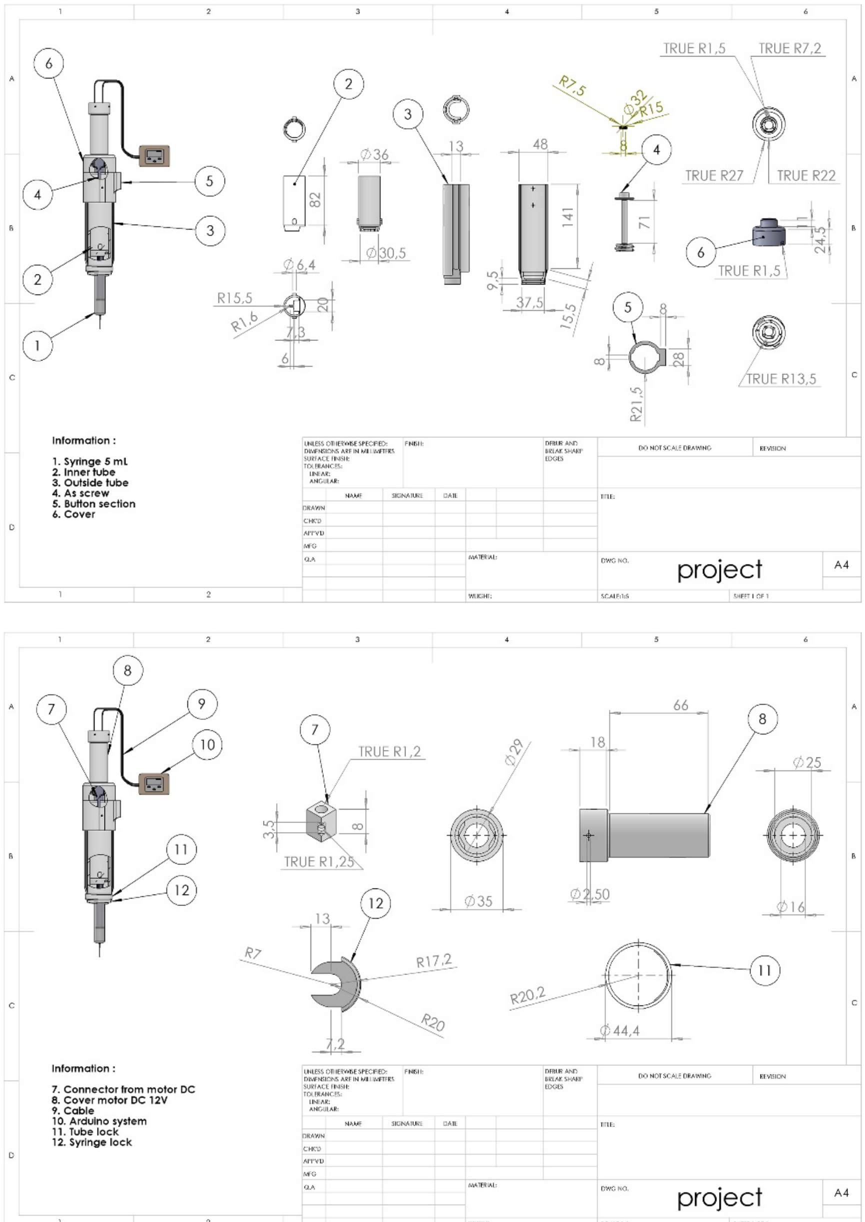

Figure 1. Design prototype adapters syringe

3.2 Participants

There were as many as 20 people who took part in the usability testing process of the syringe adapter prototype. Twenty people participated, mainly nurses who often use syringes. On the usability testing website that is usability.gov outlined the number of participants participating in the usability testing phase, 5 people already allow to find and know the purpose of usability testing. As for quantitative testing, at least 20 participants are required to get statistically significant figures (www.usability.gov). In this study it took 20 participants to get statistically significant figures. Table 1 lists the participants in the usability testing.

Table 1. Participant demographics

Sample testing		Description
Number of Respondents	20 people	A total of 20 people took part in the experiment.
Target Participants	Nurses	Nurses who work in hospitals or clinics.
Age Criteria	22-40 years old	The age range for potential respondents is 22 to 40 years old. Nurses and midwives have more experience and often use syringes, so most begin at the age of 22.
Gender Criteria	Male and female	

In this analysis, problem restrictions are needed to narrow the scope of the problem and allow for more oriented studies. The first limitation is the use of just 3 mL, 5 mL, and 10 mL syringes. The experimental subject is nurse who often uses syringes. Electromyograms will be used for muscle observation during the testing. This test is based on usability testing based on the Nielsen model (Nielsen 1994).

3.3 Experiment Procedure

The test was conducted at Sebelas Maret University Hospital, with the participant's nurse working at the hospital. Participants were shown how to operate a prototype syringe adapter with syringes of 3 mL, 5 mL and 10 mL. Participants were also shown how to choose the speed contained in the prototype that serves to speed up the injection process or aspiration when using the drug. Participants conducted tests according to research tasks. Here is a list of tasks given during testing, which can be viewed in Table 2. During the withdrawal process on the task participants will be attached electrodes to see and record the raw results of EMG, then and at the same time the withdrawal process is recorded by the stopwatch to get the average time.

Table 2. Test assignments

Test Case	Description of Test Task
1	Try using a prototype to aspiration drugs with a syringe volume of 3 mL.
2	Try using a prototype to injection drugs with a syringe volume of 3 mL.
3	Try using a prototype to aspiration drugs with a syringe volume of 5 mL using different speeds.
4	Try to use a prototype to injection drugs with a syringe volume of 5 mL using different speeds.
5	Try using a prototype for injection of the drug with a syringe volume of 10 mL.

4. Data Collection

Data collection in this study is EMG voltage plot, the time needed to fill the syringe 3 mL, 5 mL, 10 mL and make research instruments, research instruments used are Nielsen attributes of usability questionnaire. The items used in the usability test questionnaire are learnability, memorability, efficiency, errors, and satisfaction. Of the five indicators will be described in several statement items representing the experience after using the prototype syringe adapter. Here is a usability test questionnaire that can be seen in Table 3.

Table 3. Nielsen attributes of usability questionnaire

Questions
A. Learnability
1. I learned the prototype easily
2. I get specific prototype functions easily
3. I understand the features of information presented easily
4. I can understand the navigation flow easily
5. I can learn the use of prototypes without written instructions
B. Memorability
1. I remember how to use the prototype easily
2. I remember every navigation direction to easily explore the prototype features
3. I remember how to use the prototype if I used this prototype again after some time (> 1 month)
C. Efficiency
1. I can use prototypes quickly
2. I can use aspiration/injection quickly
3. I can complete test tasks quickly
D. Errors
1. I found an error while using a prototype
2. I found a feature that doesn't work according to its function
3. I didn't manage to find the feature I wanted to use
E. Satisfaction
1. I was happy overall with the prototype design
2. I feel comfortable in using prototypes
3. The composition of colors, materials and the placement of feature buttons are not confusing
4. The use of prototypes was in line with expectations I expected

All five indicators of usability testing are rated on a likert scale of 1 to 5, with 1 indicating strongly disagree, 2 indicating disagree, 3 indicating neutral or non-opinion, 4 indicating agree, and 5 indicating strongly agree.

5. Results and Discussion

5.1 Usability Testing

Before analyzing the usability test, a reliability test was conducted against the questionnaire used. The results of the reliability test conducted can be seen in Table 4. From the test, it was obtained that Cronbach's alpha was 0.772, which means that the statement is reliable.

Table 4. Reliability test

Cronbach's Alpha	N of Items
0.772	18

Descriptive statistical calculation using SPSS tools is done to see the results of the usability test conducted. In this descriptive statistical calculation, the average results of each indicator performed on the syringe adapter prototype are then divided into five categories. Table 5 shows the category and valuation range of the syringe adapter prototype.

Table 5. Rating categories and ranges

Interval	Category
0 < 1	Very Bad
1 < 2	Bad Enough
2 < 3	Good
3 < 4	Good Enough
4 ≤ 5	Excellent

The average usability test results of each indicator can be seen in Table 6. It was obtained that the learnability indicator became the aspect that had the highest rating, with a value of 4.19, meaning the prototype syringe adapter is easy to learn about navigation, features and in the absence of manual books, nurses can still run the prototype as it functions.

Table 6. Total average usability indicator

Code	Average	Average/indicator
(A1)	4.45	4.19
(A2)	4.2	
(A3)	4.05	
(A4)	4.05	
(A5)	4.2	
(B1)	4.4	4.15
(B2)	4.05	
(B3)	4	
(C1)	4	3.96
(C2)	4.05	
(C3)	3.85	
(D1)	2.4	2.33
(D2)	2.5	
(D3)	2.1	
(E1)	3.9	3.9
(E2)	3.9	
(E3)	3.95	
(E4)	3.85	

The memorability assessment became the second biggest value, with a score of 4.15, meaning that nurses can easily remember and know the use of the prototype syringe adapter. The efficiency indicator is the number 3 rating with a score of 3.96, meaning nurses can perform injections or aspirations quickly. Satisfaction became the fourth indicator in the assessment with a score of 3.9, meaning design, color, features and comfort as expected by nurses. The latter is an error indicator with a value of 2.33, meaning the nurse did not find a large error in the prototype syringe adapter and the prototype went according to function. Overall, the use of the prototype syringe adapter, nurses feel that from the design side, makes the nurse feel comfortable.

5.2 Muscle Activity

The plot of EMG voltage using the muscle activity prototype of a 3 mL syringe adapter can be seen in Figure 2A. In Figure 2A, the use of muscles carried out with the prototype appears to require slight muscle contractions marked by the use of 2.56-3.02 seconds or 6 seconds needed to withdraw 3 mL of the drug. There is a significant difference in muscle activity that occurs when using a conventional 3mL syringe. The following is a plot of the EMG voltage using a conventional syringe with a volume of 3 mL, which can be seen in Figure 2B. The use of muscles to withdraw the drug at a volume of 3 mL requires quite a lot of muscle contraction with a marked number of waves of muscle contraction and takes about 11.03-11.13 seconds or 10 seconds. Based on Figures 2A and 2B, it can be seen that the muscle activity used by the prototype is less than the conventional syringe. The difference is quite significant in the results, using the prototype of the difference in muscle use time of 4 seconds. This means that the use of muscles is less, muscle tension and fatigue are not felt efficiently by health workers, which ultimately minimizes ongoing injury to health workers.

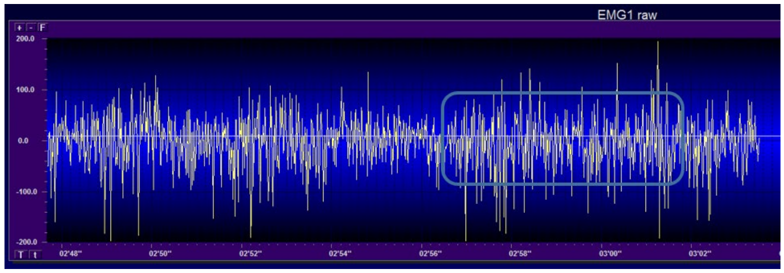

Figure 2A. Sample raw EMG withdraw 3 mL prototype

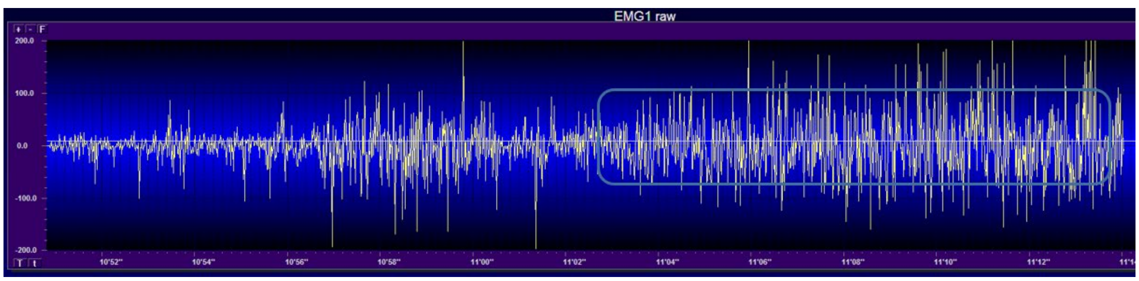

Figure 2B. Sample raw EMG withdraw 3 mL conventional syringe

The use of the muscle activity of the prototype syringe adapter with the withdrawal of the 5 mL volume of the drug is almost the same as the 3 mL volume. The plot of the EMG voltage can be seen in Figure 3A. In the picture, the time required for muscle use ranges from 05.52-05.57 seconds with muscle contractions almost the same as the withdrawal with a volume of 3 mL. In the process of drug withdrawal with a conventional syringe with a volume of 5 mL, it can be seen in Figure 3B. The EMG tension plot shows that the muscle contraction activity tends to be smaller than using the prototype, but requires a long period of muscle activity, which is indicated by the number of muscle waves that occur and the use of muscle time ranging from 13.39-13.48 seconds. Although the pulling process on the prototype produced a fairly large wave of muscle contraction, it only lasted for less than one second. In this condition, it certainly does not have a large enough effect, because when compared to the use of conventional syringes, it requires a longer muscle use time with a time difference of 4 seconds, which will produce many waves that occur. Therefore, the prototype syringe adapter uses less muscle activity than conventional syringes.

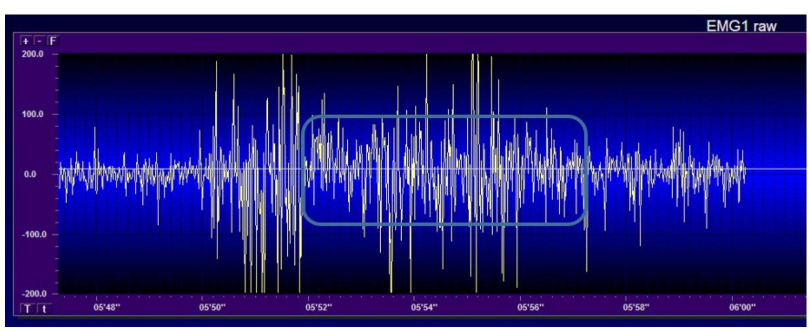

Figure 3A. Sample raw EMG withdraw 5 mL prototype

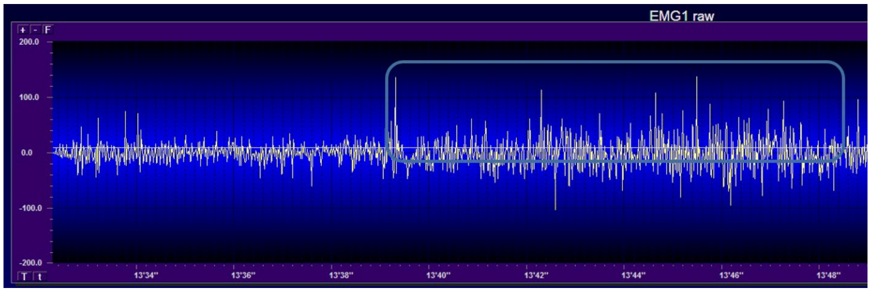

Figure 3B. Sample raw EMG withdraw 5 mL conventional syringe

The use of the muscle activity of the prototype syringe adapter to draw the drug at a volume of 10 mL experienced a big difference. It can be seen in Figure 4A that the EMG plot shows muscle contractions at the beginning and end of the process. The contractions occur when the nurse presses the button to start the process and when nurse presses it at the end of the process. The time required for muscle use is in the range of 08.08-08.13 seconds or 5 seconds. Meanwhile, withdrawing drugs with a conventional 10 mL syringe can be seen in Figure 4B. A significant difference occurs in the 10 mL volume, almost all of the time it takes for a large muscle contraction to occur. The time required for the activity is 15.51-16.12 seconds. As seen in Figures 4A and 4B, the muscle activity in the 10 mL withdrawal with the prototype uses less muscle activity than the conventional syringe. This result is marked by a very large comparison of muscle activity, the difference in muscle time used is 13 seconds. The difference in time on a conventional syringe is almost completely continuous muscle contraction. In contrast to the raw EMG results in the prototype, the resulting muscle contractions are only less than one second and do not occur continuously. This result will reduce the tension and fatigue of health workers who will withdraw drugs in hospitals, clinics and laboratories. Judging from the literature review, health workers often experience work-related musculoskeletal disorders because they perform repetitive movements and require large muscle activity. This is evident when withdrawing a conventional syringe from a volume of 3 mL to 10 mL requires large muscle activity. In this study, it can efficiently reduce work-related musculoskeletal disorders because the muscle activity used is significantly different. Characterized by the raw EMG results on the prototype syringe adapter, the muscle contraction produced is very little compared to using a conventional syringe.

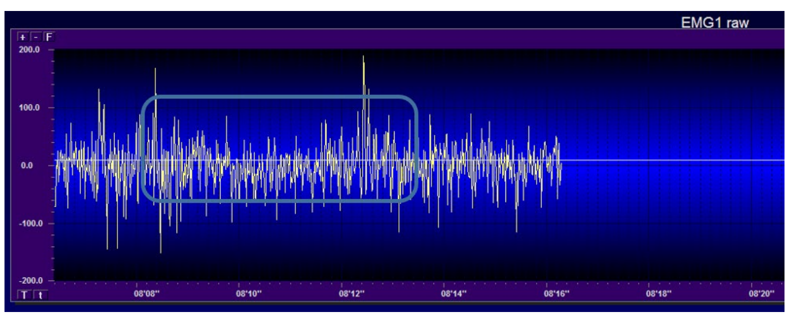

Figure 4A. Sample raw EMG withdraw 10 mL prototype

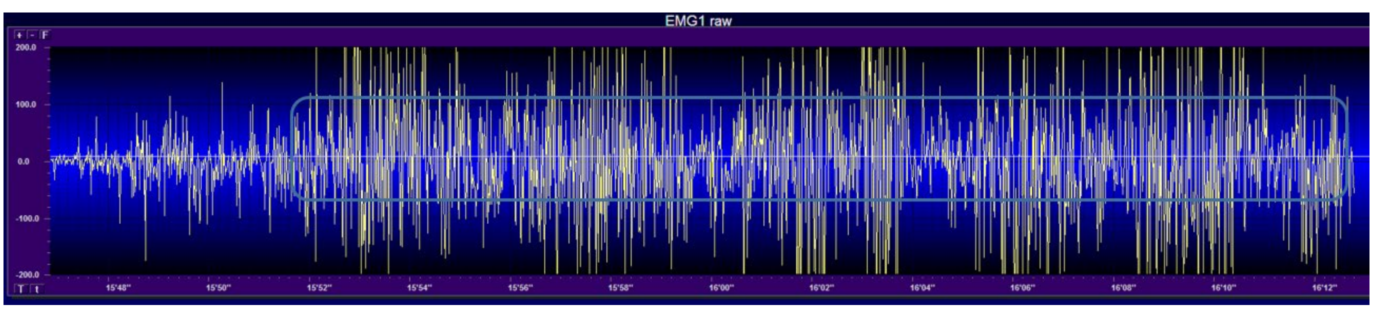

Figure 4B. Sample raw EMG withdraw 10 mL conventional syringe

5.3 Average Time Required

The average time required to fill a 3 mL tube volume with a prototype syringe adapter and a conventional syringe can be seen in Figure 5. It can be seen that there is a time difference between the prototype and a conventional syringe, the prototype takes 3.56 seconds to complete fill the 3 mL tube. While the conventional syringe takes 3.08 seconds to fill a 3 mL tube. From the time comparison, it is clear that conventional syringes fill a 3 mL tube faster than the prototype syringe adapter, but with a time difference of 0.48 seconds, the prototype syringe adapter requires less muscle to fill a 3 mL tube compared to conventional syringes require more muscle activity as it takes to fill a 3 mL tube. A time difference of less than one second is certainly not a big problem, because less than one second the difference in muscle use is not too big, so that muscle tension and fatigue are not felt by health workers. It can be seen in Figures 2A and 2B that the prototype produces less muscle contraction when compared to the muscle activity of a conventional syringe. So, this means using a prototype syringe adapter to fill 3 mL of liquid more efficiently than using a conventional syringe.

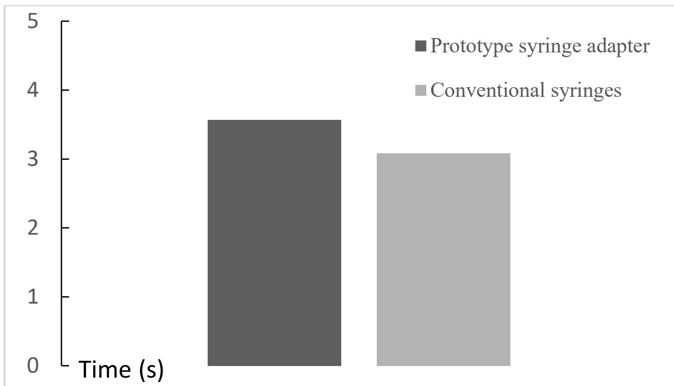

Figure 5. The average time required filling 3 mL prototype and conventional syringes

The average time required to fill a 5 mL tube with a prototype and a conventional syringe can be seen in Figure 6. From the figure it can be seen that the prototype syringe adapter also takes more time than a conventional syringe. The prototype syringe adapter took 5.53 seconds while the conventional syringe took 3.85 seconds. The prototype takes more time because the nurse has to press the button three times. After that, the new prototype will start taking the drug to be taken. Several times, the nurse squeezed so fast that the prototype could not recognize if it was pressed too fast and resulted in more time needed. Although the prototype of the syringe adapter takes a long time, the prototype requires less muscle activity. As can be seen in Figures 3A and 3B, the prototype requires less muscle contraction than a conventional syringe. It is proven that with an average time difference of 1.68 seconds to fill a 5 mL tube, but the prototype requires less muscle which is indicated by a difference in muscle use time of 4 seconds. The difference in muscle use time of 4 seconds will certainly cause a lot of muscle waves that occur compared to the time difference of 1.68 seconds to fill a 5 mL tube. This means that the prototype syringe adapter is more efficient at using the resulting muscle compared to conventional syringes.

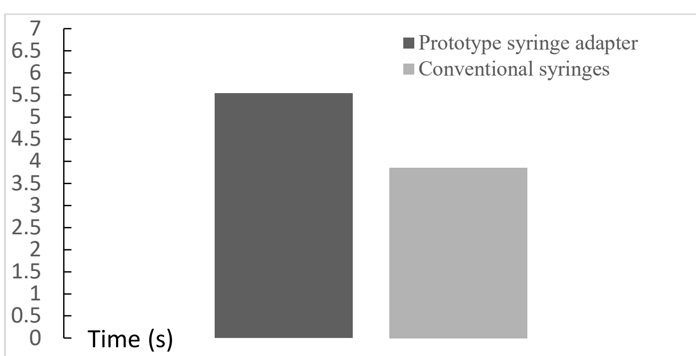

Figure 6. The average time required filling 5 mL prototype and conventional syringes

To fill a 10 mL tube, the average time required for a prototype syringe adapter and a conventional syringe can be seen in Figure 7. It can be seen that a conventional syringe takes less time than the prototype syringe adapter to fill a 10 mL tube. The conventional syringe takes 18.14 seconds while the prototype takes 19.69 seconds. The difference in time required to fill a tube containing 10 mL is 1.55 seconds. Even with a time difference of 1.55 seconds, the prototype also requires less muscle activity than conventional syringes. The required muscle activity experienced a significant difference. Muscle activity on a conventional syringe requires a longer muscle use time than the prototype syringe adapter. It can be seen in Figures 4A and 4B, the number of waves of muscle activity contracting makes a significant difference from this comparison. The prototype takes a long time because the needle in the syringe is small, while the withdrawal of the prototype is fast enough that the pressure that occurs is large enough to cause a little drug to enter the tube. But with an average time difference of 1.55 seconds to fill a 10 mL tube, the prototype is considered to be more efficient in using the required muscle activity. Marked on conventional syringes the use of muscle time is slower by 13 seconds, which means the wave of muscle contraction produced will be longer and larger. But it is faster to fill a 10 mL tube by 1.55 seconds while the prototype difference in usage time is 1.55 seconds slower for filling a 10 mL tube but with a filling time difference of 1.55 seconds, the wave of muscle activity that occurs in the prototype will not be as large as with a conventional syringe with a time difference of 13 seconds. In this case the prototype is more efficient in use than conventional syringes.

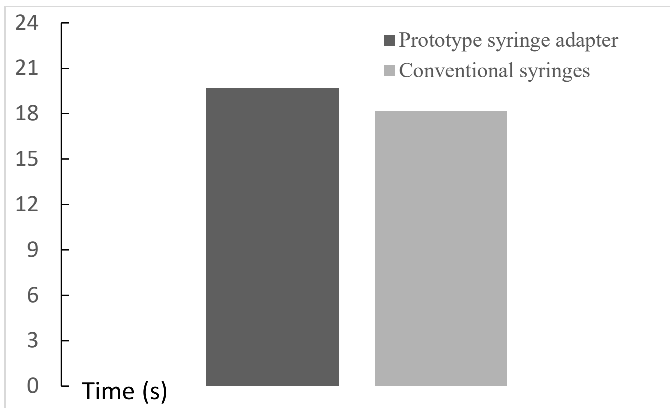

Figure 7. The average time required filling 10 mL prototype and conventional syringes

6. Conclusions

In this study, a prototype syringe adapter was developed and compared to conventional syringes to reduce the tension of muscle activity required for drug intake. The volume of the syringe used was 3 mL, 5 mL and 10 mL. Questionnaires and EMG plots were used to analyze the usability test results for the use of muscle activity. Prototype development is focused on drug uptake for patients with capacities such as hospitals and laboratories, as large capacity drug uptake can prove to be significantly successful in the development of a syringe adapter prototype.

With the usability testing questionnaire, prototypes are rated in categories both overall, from learnability indicators to satisfaction. It is proven that usability testing is tested directly on 20 nurses. On average, each indicator is in a good range and has enough errors. The prototype syringe adapter is significantly able to reduce the tension of muscle activity required for drug retrieval compared to conventional syringes. Although the time required is greater than the use of conventional syringes, but the prototype syringe adapter is able to reduce muscle activity and reduce the time of use of muscles used.

This research shows that the prototype syringe adapter is able to reduce the tension of muscle activity that occurs so as to reduce the fatigue of medical personnel and reduce musculoskeletal disorders. Future research will be conducted to develop a prototype design of a syringe adapter to reduce fatigue and musculoskeletal disorders with syringes with volumes of 20 mL to 50 mL.

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