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Cała załoga METRUM CRYOFLEX od zawsze trzymała kciuki za Narodową Kadrę Skoczków Narciarskich, a od lipca 2020 roku może wspierać ich również sprzętowo.

Skoczkowie polskiej kadry są pod doskonałą opieką profesjonalnego sztabu, który codziennie dba o ich dobrą kondycję i zdrowie. METRUM CRYOFLEX poprzez podpisaną umowę stało się częścią tego medalowego zespołu, a dostarczony przez nich sprzęt pomaga w regeneracji skoczków po obciążających treningach i zawodach, umożliwiając szybki powrót do formy.

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nr 4/2021 (21)

Assessment of the effects of therapy with the use of the Fourier M2 neurological smart robot in post-stroke patients with hemiplegia

Ocena efektów terapii z wykorzystaniem inteligentnego robota neurologicznego Fourier M2 u chorych po udarze mózgu z niedowładem połowiczym

Igor Świerkowski[1(A,B,C,D,F)], Marcin Krajczy[2(A,D,G)], Ewa Jach[1(E,F)], Piotr Kęsicki[1(E,F)], Katarzyna Bogacz[1,3(D,G)], Jacek Łuniewski[1(D,G)], Jan Szczegielniak[1,3(C,G)]

[1]Politechnika Opolska / Opole University of Technology, Opole, Poland
[2]Szpital Miejski w Nysie / Nysa City Hospital, Poland
[2]Szpital Specjalistyczny MSWiA w Głuchołazach / Specialist Hospital of the Ministry of the Interior and Administration in Głuchołazy, Poland

Abstract
Objective. The objective of the study is to assess the effect of upper limb therapy with the use of the Fourier M2 smart robot in post-stroke patients with right and left hemiplegia. Material and methods. The study included 13 post-stroke patients with hemiplegia. The study group consisted of 11 men and 2 women. Eight patients experienced a left-sided stroke and five patients experienced a right-sided stroke. The patients were assessed using the Fourier M2 robot. Inclusion criteria for the study were the occurrence of a stroke, hemiplegia, dysfunction of the upper limb, and restricted mobility. The patients underwent a 10-day therapy with the use of the Fourier M2 smart robot, which is used for diagnostics, planning and conducting therapy. Statistical calculations were performed using the Statscloud application. Results: On the first day, the caloric values were lower (Mdn = 1.60) than on the last day (Mdn = 3.60), which proves the effects of using a smart robot in the neurorehabilitation of post-stroke patients. The Wilcoxon test shows a statistically significant difference: z = −3.18; p = 0.003, r = −0.62. On the first day, the result was lower (Mdn = 1,231.00) compared to the last day (Mdn = 1,591.00), which proves the effects of using a smart robot in the neurorehabilitation of post-stroke patients. The Wilcoxon test shows a statistically significant difference: z = −2.48; p = 0.018, r = −0.49. On the last day, the score values are higher (M = 196.85, SD = 93.14) than on the first day (M = 137.46, SD = 99.96), which proves the effects of using a smart robot in the neurorehabilitation of post-stroke patients. The T-test shows that the difference was statistically significant: t(12) = −3.22; p = 0.007, Cohen dav = 0.62, observed force = 0.32. With a random pair of values, there is a 73.08% chance that the last day's value would be higher than the first day's value. On the first day, the distance values were lower (Mdn = 23.00) than on the last day (Mdn = 52.80), which proves the effects of using a smart robot in the neurorehabilitation of post-stroke patients. The Wilcoxon test shows that the difference was statistically significant: z = −3.11; p = 0.003, r = −0.61. On the first day, the average speed values were lower (Mdn = 4.50) than on the last day (Mdn = 4.60), which proves the effects of using a smart robot in the neurorehabilitation of post-stroke patients. The Wilcoxon test shows that the difference is statistically significant: z = −2.76; p = 0.009, r = −0.54. On the first day, the proportion of active movement was higher (M = 27.25, SD = 21.72) than on the last day (M = 25.54, SD = 24.73), which does not prove the effects of using a smart robot in neurorehabilitation stroke patients. The T-test shows that the difference was not statistically significant: t(12) = 0.31, p = 0.758, Cohen dav = 0.07, observed force = 0.04. In the case of a pair of randomly selected values, there is a 52.93% chance that the values on the first day would be higher than on the last day.
Conclusions. 1. The use of the Fourier M2 smart robot does not have a positive effect on increasing the proportion of active movement in post-stroke patients with hemiplegia. 2. The use of the Fourier M2 smart robot has a positive effect on the improvement of the average speed of movement in post-patients with hemiplegia.
3. The use of the Fourier M2 smart robot has a positive effect on increasing the functionality of the upper limb in post-stroke patients with hemiplegia.

Key words:
stroke, neurology, robot, upper limb, hemiplegia

Streszczenie
Cel pracy. Celem pracy jest ocena wpływu terapii kończyny górnej z wykorzystaniem inteligentnego robota Fourier M2 u chorych po udarze mózgu z niedowładem połowiczym, prawo- i lewostronnym. Materiał i metodyka. Badaniem zostało objętych 13 pacjentów z porażeniem połowiczym występującym w wyniku incydentu udarowego. Grupę badawczą stanowiło 11 mężczyzn oraz 2 kobiety. U 8 pacjentów wystąpił udar lewostronny, natomiast u 5 osób prawostronny. Badani zostali ocenieni przy pomocy robota do rehabilitacji Fourier M2. Kryteriami włączenia do badania było wystąpienie incydentu udarowego, porażenie połowicze, dysfunkcja kończyny górnej oraz ograniczenie ruchomości. Chorzy byli poddani 10-dniowej terapii z wykorzystaniem inteligentnego robota Fourier M2, który służy do diagnostyki, planowania oraz przeprowadzenia terapii. Obliczenia statystyczne zostały przeprowadzone przy użyciu aplikacji Statscloud. Wyniki. W pierwszy dzień wartości kalorii były niższe (Mdn = 1,60) niż w trakcie ostatniego dnia (Mdn = 3,60), co świadczy o efektach wykorzystania inteligentnego robota w neurorehabilitacji pacjentów po udarze mózgu. Test Wilcoxona wykazuje różnicę, która jest istotna statystycznie: z = −3,18; p = 0,003, r = −0,62. W pierwszy dzień wynik był niższy (Mdn = 1231,00) w porównaniu do ostatniego dnia (Mdn = 1591,00), co świadczy o efektach wykorzystania inteligentnego robota w neurorehabilitacji pacjentów po udarze mózgu. Test Wilcoxona pokazuje różnicę, która jest istotna statystycznie: z = −2,48; p = 0,018, r = −0,49. W ostatni dzień wartości dla punktów są wyższe (M = 196,85, SD = 93,14) niż w trakcie pierwszego dnia (M = 137,46, SD = 99,96), co świadczy o efektach wykorzystania inteligentnego robota w neurorehabilitacji pacjentów po udarze mózgu. T-test pokazuje, że różnica była istotna statystycznie: t(12) = −3,22; p = 0,007, Cohen dav = 0,62, zaobserwowana siła = 0,32. W przypadku pary losowo wybranych wartości istnieje 73,08% szans, że wartość z ostatniego dnia będzie wyższa niż wartość w trakcie pierwszego dnia. W pierwszy dzień wartości dla dystansu były niższe (Mdn = 23,00) niż w trakcie ostatniego dnia (Mdn = 52,80), co świadczy o efektach wykorzystania inteligentnego robota w neurorehabilitacji pacjentów po udarze mózgu. Test Wilcoxona pokazuje, że różnica była istotna statystycznie: z = −3,11; p = 0,003, r = −0,61.W pierwszy dzień wartości dla średniej prędkości są niższe (Mdn = 4,50) niż w trakcie ostatniego dnia (Mdn = 4,60), co świadczy o efektach wykorzystania inteligentnego robota w neurorehabilitacji pacjentów po udarze mózgu. Test Wilcoxona pokazuje, że różnica jest istotna statystycznie: z = −2,76; p = 0,009, r = −0,54. W pierwszy dzień proporcja ruchu aktywnego była wyższa (M = 27,25, SD = 21,72) niż w trakcie ostatniego dnia (M = 25,54, SD = 24,73), co nie świadczy o efektach wykorzystania inteligentnego robota w neurorehabilitacji pacjentów po udarze mózgu. T-test pokazuje, że różnica nie była istotna statystycznie: t(12) = 0,31, p = 0,758, Cohen dav = 0,07, zaobserwowana siła = 0,04. W przypadku pary wybranych losowo wartości jest 52,93% szans, że wartości z pierwszego dnia będą wyższe niż w trakcie ostatniego dnia. Wnioski: 1. Wykorzystanie inteligentnego robota Fourier M2 nie wpływa pozytywnie na zwiększenie proporcji ruchu aktywnego u pacjentów po udarze mózgu z porażeniem połowiczym. 2. Wykorzystanie inteligentnego robota Fourier M2 wpływa pozytywnie na poprawę średniej prędkości ruchu u pacjentów po udarze mózgu z porażeniem połowiczym.
3. Wykorzystanie inteligentnego robota Fourier M2 wpływa pozytywnie na zwiększenie funkcjonalności kończyny górnej u pacjentów po udarze mózgu z porażeniem połowiczym.

Słowa kluczowe:
udar, neurologia, robot, kończyna górna, porażenie połowicze

Introduction

Recently, many forms of physiotherapy have been enriched with the use of modern devices supporting diagnostics, standard procedures and positively influencing the final effects of therapy. This is especially true of areas where treatment may be difficult and not very effective according to patients and therapists. Kinesiotherapy, physical therapy or specialized methods, such as Bobath or PNF, are therefore supplemented by robots or other technological innovations, based in their work on the biomechanics and anatomy of the human body. A significant benefit is their use not only after single, difficult surgical incidents, but also the possibility of using them in patients with disorders such as, for example, hemiplegia resulting from a stroke, which is one of the most common civilization diseases. It is severe enough that it carries a substantial risk of disability, which may include a wide range of symptoms. More than half of the patients struggle with complications even many years after a stroke. The degree of the patient's disability depends on the level of neurological deficit. The most common complications include aphasia and motor disorders, which often affect the functioning of the upper limb, essential for everyday activities. Three months after a stroke, only 12% of survivors do not report any problems with the functioning of the hand, and 38% report difficulties in the proper functioning of the hand [10]. Fast and effective therapeutic management is essential to prevent tendon contracture, spasticity or pain [5]. Restoring the function and efficiency of the hand is a long and burdensome process [24]. Based on the phenomenon of neuroplasticity of the brain, smart therapy devices are designed to prevent the formation or consolidation of pathological movement patterns induced by a stroke through repetitive, precise tasks and exercises. Examples include HandTutor or Fourier M2 robots supporting upper limb physiotherapy. The positive effects of using smart devices are a pretext for their frequent use and expansion of standard rehabilitation programs, which in the light of the presented research, seems to be a very right decision. This study presents a diagram of a physiotherapeutic procedure involving the Fourier M2 robot used after a stroke resulting in hemiplegia, and describes the aspects related to working with similar devices in physiotherapy. Physiotherapy of post-stroke patients with hemiplegia is difficult due to the resulting limitations. Hemiplegia prevents post-stoke patients from performing everyday activities, and in some cases the patients become severely disabled. Low mobility in the joints, muscle weakness and contractures lead to a reduction in physical activity. These factors reduce the quality of life and the regression of patients' physical fitness [3, 10, 12, 16, 20].

Objective

The objective of the study was to assess the effect of upper limb therapy with the use of the Fourier M2 smart robot in post-stroke patients with right and left hemiplegia.

Material and methods

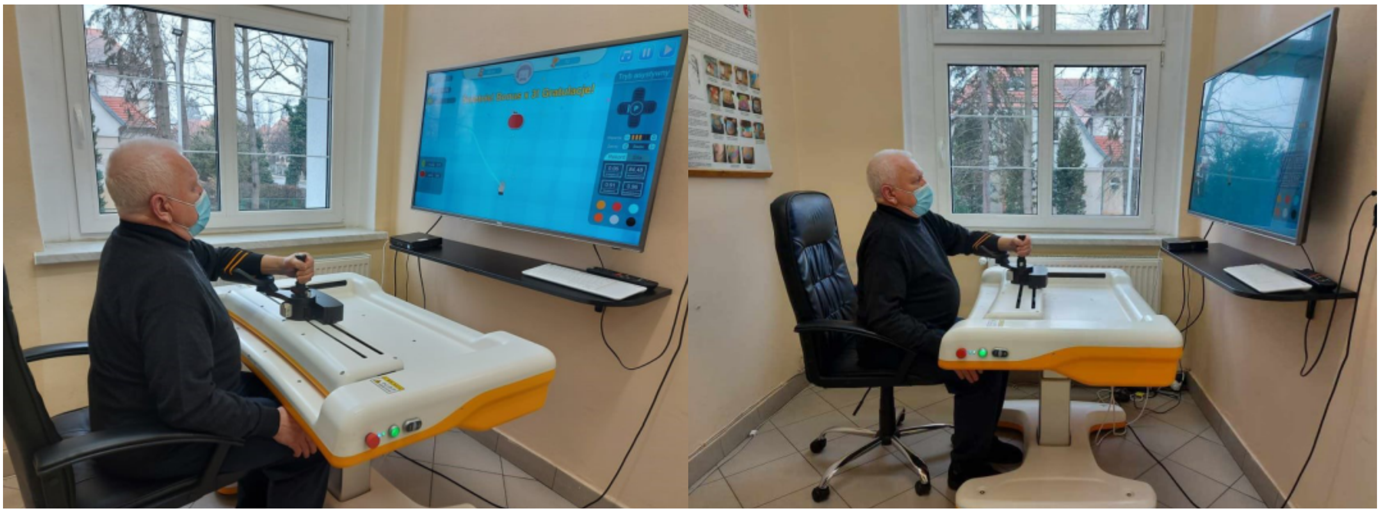
The plan was to conduct a study involving a large number of post-stroke patients with hemiplegia. It was supposed to be a selected group with a similar level of fitness in a certain age range, but the COVID-19 pandemic caused by the SARS COV-2 coronavirus made it difficult to perform the study in this form. Ultimately, the small number of patients participating in the study was conditioned by the strict terms of hospitalization. The study included 13 post-stroke patients with hemiplegia. The study group consisted of 11 men and 2 women. Eight patients experienced a left-sided stroke and five patients experienced a right-sided stroke.

The patients were assessed using the Fourier M2 robot. Inclusion criteria for the study were the occurrence of a stroke, hemiplegia, dysfunction of the upper limb, and restricted mobility.

The patients underwent a 10-day therapy with the use of the Fourier M2 smart robot, which is used for diagnostics, planning and conducting therapy. The robot is used to improve the functionality of the upper limb.

The indices analysed during the study include the number of calories burned (kcal), the result obtained during the training session, the score gained, the distance that the patient covered to reach the goal, the patient's average speed, the proportion of active movements. All patients underwent assistive training.

The training involved the patient following an icon that appeared on the screen with his/her upper limb (using a joystick). The score reflected the number of hits by the patient on the icon. The average speed corresponded to the speed at which the patient scrolled over the image as it appeared. The proportion of active movement shows a correlation of the percentage of the movement performed by the patient in relation to the movement performed with the assistance of a robot. The distance was the distance covered by the patient during one training session.



Rycina 1. Pacjent w trakcie sesji terapeutycznej. Źródło: własne
Figure 1. Patient during a therapy session. Source: own elaboration

Statistical methods

Statistical calculations were performed using the Statscloud application. The results of each of the indices (calories burnt, distance covered, result, score, average speed, proportion of active movement) were compared on the first day of therapy and on the last day using the Wilcoxon test and T-test, which allowed for the determination whether they are statistically significant. The results were also measured for a monotonic statistical correlation between random variables using the Spearman's rank correlation coefficient. The last test used for the statistical analysis was the Pearson correlation coefficient, which allows to determine the level of linear correlation between random variables.

Results

Assessment of calories burnt in the first and last test in patients after a cerebral stroke rehabilitated with the use of the Fourier M2 smart robot

The calories burnt were measured on the first and last day of the training sessions.

Table 1. Assessment of calories burnt during the training session in the first and last test in patients rehabilitated with the use of the Fourier M robot 2

Group		Descriptive statistics			Test statistics		
Result	Group	n	mean	SD	W	z	p
Kcal	First	13	2.415	1.971	0.000	−3.180	0.003
	Last	13	3.338	1.791			

SD: standard deviation

On the first day, the values of calories burnt were lower (Mdn = 1.60) than on the last day (Mdn = 3.60), which proves the positive effects of using a smart robot in the neurorehabilitation of post-stroke patients. The Wilcoxon test showed a statistically significant difference, $z = -3.18$; $p = 0.003$, $r = -0.62$.

Assessment of the obtained result in the first and last test in patients after a cerebral stroke rehabilitated with the use of the Fourier M2 smart robot

The achieved result was measured on the first and last day of the training sessions.

Table 2. The result obtained during the training sessions in the first and last test in patients rehabilitated with the use of the Fourier M2 robot

Group		Descriptive statistics			Test statistics		
Result	Group	n	średnia/mean	SD	W	z	p
Result	Pierwszy/First	13	1661.462	1393.411	10	−2.481	0.018
	Ostatni/Last	13	2197.769	1263.296			

SD: standard deviation

On the first day, the result was lower (Mdn = 1,231.00) compared to the last day (Mdn = 1,591.00), which proves the positive effects of using a smart robot in the neureorehabilitation of post-patients. The Wilcoxon test showed a statistically significant difference: z = −2.48; p = 0.018, r = −0.49.

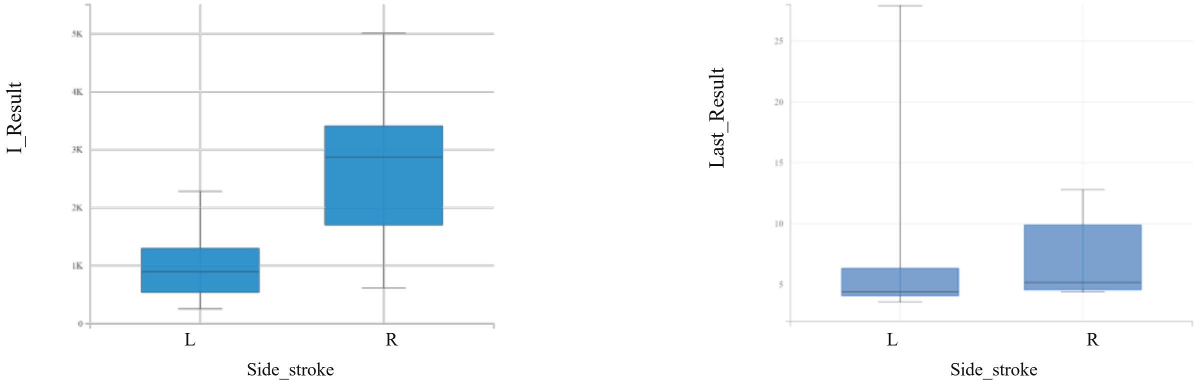


Figure 2. Comparison of the results on the first and the last day of therapy in people with right and left hemiplegia

Assessment of the score obtained in the first and last test in patients after a cerebral stroke rehabilitated with the use of the Fourier M2 smart robot

The achieved score was measured on the first and the last day of the training sessions.

Table 3. Score obtained during the training sessions in the first and last test in patients rehabilitated with the use of the Fourier M2 robot

Group		Descriptive statistics			Test statistics			Effect size	
Result	Group	n	mean	stand. dev.	df	t	p	Cohen's d	Hedges' g
Score	Pierwszy/First	13	137.462	99.956	12	−3.215	0.007	0.62	0.60
	Ostatni/Last	13	196.846	93.136					

On the last day, the score was higher (M = 196.85, SD = 93.14) than on the first day (M = 137.46, SD = 99.96), which proves the positive effects of using a smart robot in neurorehabilitation of post-stroke patients. The T-test shows that the difference was statistically significant: t (12) = −3.22; p = 0.007, Cohen d_{av} = 0.62, observed force = 0.32.

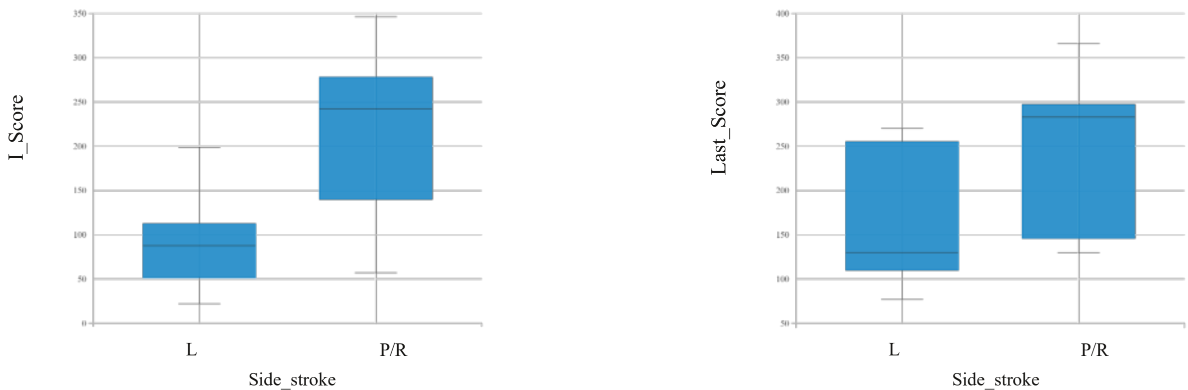


Figure 3. Comparison of the score for patients with right and left hemiplegia on the 1st day and on the last day of therapy

With a random pair of values, there is a 73.08% chance that the last day's value would be higher than the first day's value.

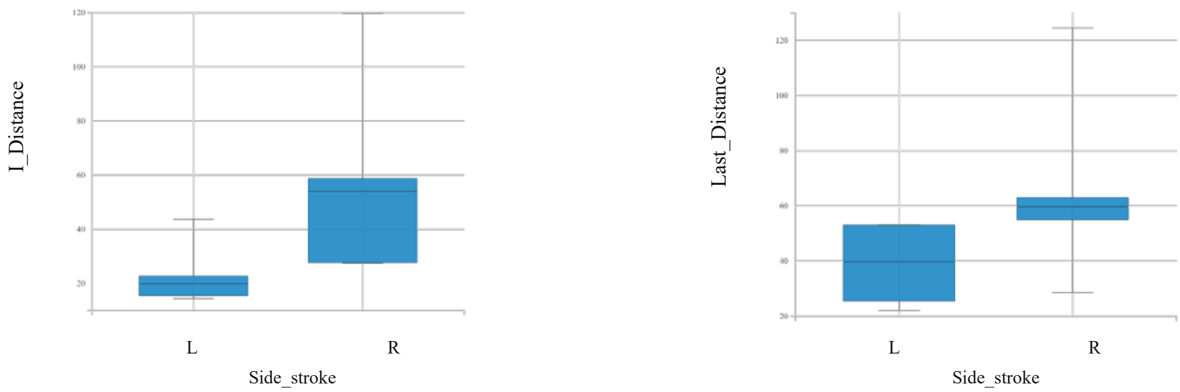
Assessment of the distance covered in the first and last test by patients after a cerebral stroke rehabilitated with the use of the Fourier M2 smart robot
The distance covered by patients was measured on the first and the last day of the training sessions.

Table 4. Distance covered during the training sessions in the first and last test in patients rehabilitated with the use of the Fourier M2 robot

Group		Descriptive statistics			Test statistics		
Result	Group	n	mean	SD	W	z	p
Dystans/ Distance	Pierwszy/First	13	35.492	29.168	1	−3.110	0.003
	Ostatni/Last	13	49.431	26.637			

SD: standard deviation

On the first day, the distance values were lower (Mdn = 23.00) than on the last day (Mdn = 52.80), which proves the positive effects of using a smart robot in the neurorehabilitation of post-patients. The Wilcoxon test shows that the difference was statistically significant: $z = -3.11$; $p = 0.003$, $r = -0.61$.



Rycina 4. Porównanie dystansu w 1 i ostatnim dniu terapii u osób z porażeniem prawo- i lewostronnym
Figure 4. Comparison of the distance on the first and the last day of therapy in patients with right and left hemiplegia

Assessment of the average speed value achieved in the first and last test by patients after a cerebral stroke rehabilitated with the use of the Fourier M2 smart robot
The average speed achieved by the patients was measured on the first and the last day of the training sessions.

Table 5. Average speed achieved during the training sessions in the first and last test in patients rehabilitated with the use of the Fourier M2 robot

Group		Descriptive statistics			Test statistics		
Result	Group	n	mean	SD	W	z	p
Average speed	First	13	5.108	2.823	6	−2.764	0.009
	Last	13	7.546	6.671			

SD: standard deviation

On the first day, the values for the average speed were lower (Mdn = 4.50) than on the last day (Mdn = 4.60), which proves the positive effects of using a smart robot in the neurorehabilitation of post-stroke patients. The Wilcoxon test shows that the difference is statistically significant: $z = -2.76$; $p = 0.009$, $r = -0.54$.

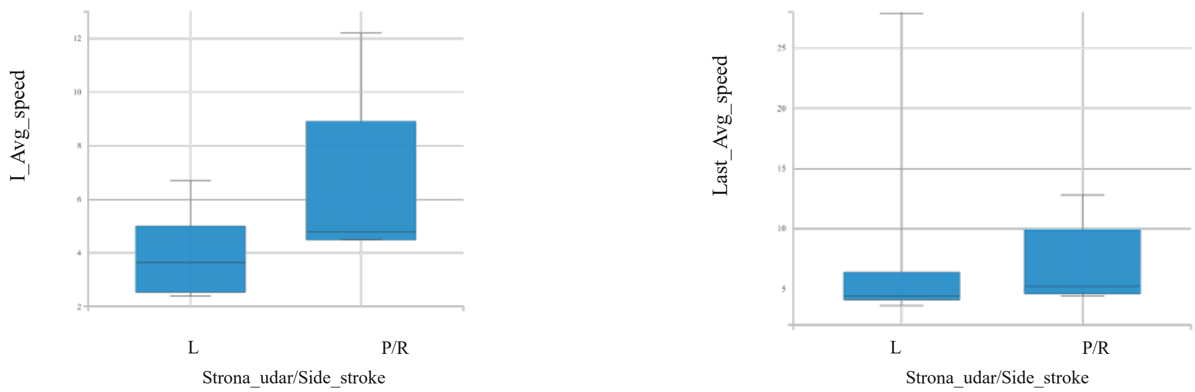


Figure 5. Comparison of the average speed on the first and last day of therapy in patients with right and left hemiplegia

Assessment of the proportion of active movement achieved in the first and last test by patients after a cerebral stroke rehabilitated with the use of the Fourier M2 smart robot

The proportion of active movement achieved by the patients was measured on the first and the last day of the training sessions.

Table 6. Proportion of active movement obtained during the training sessions in the first and last test in patients rehabilitated with the use of the Fourier M2 robot

Group		Descriptive statistics			Test statistics			Effect size	
Result	Group	n	mean	stand. dev.	df	t	p	Cohen's d	Hedges' g
Proportion of active movement	First	13	27.246	21.716	12	0.315	0.758	0.07	0.07
	Last	13	25.538	24.730					

On the first day, the proportion of active movement was higher (M = 27.25, SD = 21.72) than on the last day (M = 25.54, SD = 24.73), which does not prove the effects of using a smart robot in neurorehabilitation of post-stroke patients. The T-test shows that the difference was not statistically significant: $t(12) = 0.31$, $p = 0.758$, Cohen $d_{av} = 0.07$, observed force = 0.04. In the case of a pair of randomly selected values, there is a 52.93% chance that the values on the first day would be higher than on the last day.

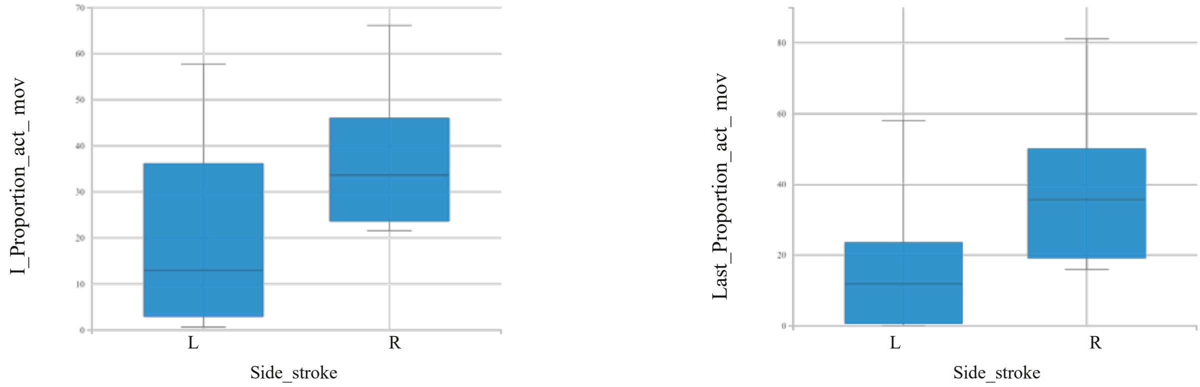


Figure 6. Comparison of the proportion of active movement on the first and last day of therapy in patients with right and left hemiplegia

Discussion

Stroke is one of the most common causes of death in the world. The number of stroke patients increases every year. It leads to serious complications, including hemiplegia (uni- or bilateral), and in the most severe cases to permanent disability. A significant problem is the regression of the functionality of the upper limb in post-stroke patients. This dysfunction has a negative impact on patients' quality of life and makes it difficult for them to perform daily activities, which is why it is so important to quickly undertake therapeutic rehabilitation within the affected limb. Rehabilitation of the upper limb is a long, demanding and difficult process. The main goal of this procedure is to reduce/prevent contractures, improve the range of motion and the functional state.

With technical progress, alternative techniques have joined the traditional methods used in physiotherapy. An attractive form is the use of the Fourier M2 smart robot, which is used not only for therapy, but also for the evaluation and diagnosis. This device offers therapy in various modes, so that the rehabilitation can be adjusted individually for each patient.

The author's study describes the impact of the Fourier M2 smart robot on a group of 13 post-stroke patients with hemiplegia. The aim of rehabilitation was to increase mobility in the upper limb and improve its functionality. The patients underwent 10 sessions with the use of a robot which, apart from the training function, also evaluated each patient during the training session. All but one index (proportion of active movement) showed statistical significance. The study compared the achieved values of indices (number of calories burnt, result, score, average speed and proportion of active movement) on the first and the last day of the training sessions with the use of the Fourier M2 smart robot. For the calories index, the statistical significance was p = 0.003; the value of calories burnt on the first day was lower than on the last one. For the index concerning the result achieved by the patient during the training sessions, the statistical significance was p = 0.018; the value of the result on the first day was lower than on the last one. For the index concerning the score achieved by the patient in the training sessions, the statistical significance was p = 0.007; the score achieved on the first day was lower than on the last one. For the distance, the statistical significance was p = 0.003; the distance achieved on the first day was lower than on the last day. For the average speed achieved by the patient during the therapeutic session, the statistical significance was p = 0.009; the average speed achieved on the first day was lower than on the last one. The proportion of active movement did not show statistical significance as it was p = 0.758; the proportion of active movement on the first day was higher than on the last day.

These results prove that the use of the Fourier M2 smart robot positively influences the improvement of the functional state of the upper limb. The only reservation is that due to the lack of a control group in the conducted studies, it was not possible to compare the results.

Caimmi et al., conducting studies using a robot similar to Fourier M2, showed that neurophysiotherapeutic interventions of this type constitute an effective form of supporting the treatment process, taking into account the short duration of the intervention itself and at the same time a long period during which therapy can be applied after a stroke. The studies consisted in assessing 10 patients with a hand-to-mouth test who developed hemiplegia as a result of a stroke. The patients underwent a 12-day session with the use of a rehabilitation robot. One training session lasted 20 minutes and was conducted in a passive mode. The tool used to evaluate therapy was the Fugl-Meyer test. Only one patient showed no functional improvement. Improvement in the functionality of the upper limb was reported by patients even up to six months after the end of the physiotherapeutic treatment [3].

The results of studies conducted by Rosati G. et al., who studied a group of 24 post-stroke patients, also refer directly to therapy of the upper limb. The patients were divided into two groups, where the control group underwent only standard physiotherapy, and the study group additionally had sessions with the use of a neurological robot. As in the previously described study, the tool used for the evaluation was the Fugl-Meyer test. The results of the study proved better effects of therapy in the group that was also stimulated with the use of a smart robot [21].

Masier S. et al. divided 20 patients into two groups, one of which underwent standard physiotherapy, and the study group additionally had training with the use of a neurorobot. The results of the study showed improvement in both groups, however, the results were better in the patients who used the robot. The effects of therapy lasted up to 3 months after its completion. It seems important that the modern form of therapy supported by a robot is positively received by patients, which directly translates into increased commitment and motivation [18].

Gait training using a lokomat is an effective additional tool used in physiotherapeutic programs in the treatment of children with hemiplegia, as it plays a significant role in reducing spasticity and improving the patient's gait pattern [17].
Dynamic taping can also be a supplement to comprehensive upper limb physiotherapy with the use of the Fourier M2 robot, as presented in the study conducted by Krajczy et al. The study was conducted on 28 post-stroke patients who were divided into two groups. The control group had sessions using the Fourier M2 smart robot, while in the study group additionally dynamic taping, the purpose of which was to normalize the muscle tone in the forearm, hand and shoulder joint on the affected side. The results showed positive effects of both the robot and dynamic taping. The study group had their index values (result, distance, average speed, proportion of active movement, energy expenditure) compared on the first and last day of therapy with the use of the Fourier M2 smart robot and the application of dynamic taping on the upper limb. The index concerning the result achieved by post-stroke patients was statistically significant: $p = 0.020$. The distance index in patients was statistically significant and amounted to $p = 0.003$. The average speed index concerning the performance of tasks during training with the use of the Fourier M2 robot was statistically significant: $p = 0.003$. The index of the proportion of active movement was not statistically significant: $p = 0.337$. The index of energy expenditure in patients after a stroke obtained during training with the use of the Fourier M2 robot was statistically significant: $p = 0.017$. It should be noted that the author of the above study, apart from the Fourier M2 robot, also used dynamic taping in the area of the upper limb. When analysing the results of dynamic taping and other studies, it should be assumed that dynamic taping itself could have a considerable influence on the statistical significance [12].
The innovativeness of physiotherapy manifests itself not only in the area of robotization, but also in the form of increasingly common virtual reality. Thanks to the use of immersive applications, which constitute an attractive form of therapy for patients, who become more involved during their training sessions. This method, using neuroplasticity of the brain, is helpful in patients with various dysfunctions, not only neurological [14].
Considering the recent publications in the field of neurorehabilitation, one more conclusion arises: regardless of whether the assessed form of therapy focuses on innovative methods or takes into account the most conventional techniques, it is usually not as effective separately as when used jointly.
The positive effects of using a smart robot in patients with right or left hemiplegia are evidenced by the progress in the values of calories burnt, distance covered, result, score and average speed. The conducted study confirms the earlier assumption that rehabilitation with the use of the Fourier M2 smart robot has a positive effect on the improvement of the functionality of the upper limb in the study participants. The use of a robot is one of the methods of physiotherapeutic management that can be used to achieve the desired effects in a short time, such as increasing the average speed of exercises or burning calories during a training session. The results involving the proportion of active movement were most likely in-

fluenced by the small number of patients participating in the study, the lack of a control group and the lack of patients' involvement in training. This assumption seems to be true when analysing the results of studies conducted by Krajczy et al., which showed a significant improvement (46.09 before therapy, 55.68 after therapy) in the proportion of active movement in the studied group of 28 patients [12].
Based on the cited studies of other authors and the presented study, it can be concluded that smart robots in combination with traditional methods of rehabilitation determine the future of physiotherapy in various diseases.

Conclusions

1. The use of the Fourier M2 smart robot does not have a positive effect on increasing the proportion of active movement in post-stroke patients with hemiplegia.
2. The use of the Fourier M2 smart robot has a positive effect on the improvement of the average speed of movement in post-stroke patients with hemiplegia.
3. The use of the Fourier M2 smart robot has a positive effect on increasing the functionality of the upper limb in post-stroke patients with hemiplegia.

Adres do korespondencji / Corresponding author

Katarzyna Bogacz

e-mail: k.bogacz@interia.pl

Piśmiennictwo/ References

1. Błażejewska-Hyżorek B. i wsp., Wytyczne postępowania w udarze mózgu, Polski Przegląd Neruologiczny, 2019, tom 15, supl. A.
2. Bochenek A., Reicher M., Anatomia człowieka, tom 1, Podręcznik dla studentów medycyny i lekarzy, PZWL, Warszawa 2010.
3. Caimmi M. i wsp., Using robot fully assisted functional movements in upper-limb rehabilitation of chronic stroke patients: preliminary results, European Journal of Physical and Rehabilitation Medicine, 2017, 53(3); s.390-399.
4. Corbetta D. i wsp., Constraint-induced movement therapy for upper extermities in people after stroke, The Cochrane Database of systematic reviews, 2015, 8(10).
5. Hoffman J. i wsp., Rehabilitacja kończyny górnej po udarze mózgu, Choroby XXI wieku – wyzwania w pracy fizjoterapeuty, pod red. Podgórskiej M., Gdańsk 2017, Wydawnictwo Wyższej Szkoły Zarządzania.
6. Kahn L., Lum P., Reinkensmeyer D., Selection of Robotic Therapy Algorithms for the Upper Extermity in Chronic Stroke: Insights form MIME and ARM Guide Results, Proceedings of the 8th International Conference on Rehabilitation Robotics, ICORR 2003, s. 208-210.
7. Kaniewski O., i wsp., Wpływ terapii PNF na proces poprawy motorycznej u pacjentów po niedokrwiennym udarze mózgu zlokalizowanym w lewej półkuli w okresie ostrym rehabilitacji, Annales Acadamiae Medicae Silesiensis, 2014, 68, 5, s.294-301.
8. Kapandji A., Anatomia funkcjonalna stawów, tom 1: Kończyna górna, 2013, Wydawnictwo Medyczne Edra & Urban, 2013.
9. Kaźmierski R., Diagnostyka i leczenie chorych w ostrej fazie udaru niedokrwiennego mózgu, Anestezjologia i Ratownictwo, 2014, 8, s:62-75.
10. Kiper A. i wsp., Wpływ innowacyjnych technologii na usprawnianie kończyny górnej u chorych po udarze mózgu, Rehabilitacja w geriatrii, 2016, 2.
11. Kowiański P. Lietzau G., Moryś J., Budowa i funkcje układu żylnego w ośrodkowym układzie nerwowym, Udar Mózgu. Problemy Interdyscyplinarne 2010; 12(1-2): 36-41.
12. Krajczy i wsp., Ocena efektów plastrowania dynamicznego (PD) z wykorzystaniem inteligentnego robota Fourier M2 u chorych po udarze mózgu z niedowładem połowiczym, Fizjoterapia Polska, 2018, 18(1), s.32-48.
13. Lambercy O., i wsp., Effects of a robot-assisted training of grasp and pronation/supination in chronic stroke: a pilot study, Journal of Neuro Engineering and Rehabilitation, 2011, 8:63.
14. Laver K., i wsp., Virtual reality for stroke rehabilitation, The Cochrane Database of systematic reviews, 2017 (11).
15. Lum P., i wsp., MIME robotic device for upper-limb neurorehabilitation in subacute stroke subjects: a follow-up study, Journal of Rehabilitation & Development, 2006, 43(6): s. 631-642.
16. Lum P., i wsp., Robotic Approaches for Rehabilitation of Hand Function After Stroke, American Journal of Physical Medicine and Rehabilitation, 2012, 91, s. 242-254.
17. Mahgoub E. S. M., Amin W. W., Zahran S. S., Effect of locomotor training with a robotic-gait orthosis (lokomat) in Spasticity Modulation of Spastic Hemiplegic Children: A Randomized Controlled Trial, Fizjoterapia Polska, 2020; 20(4); s.94-101.
18. Masier S. i wsp., A novel robot device in rehabilitation of post-stroke hemiplegic upper limbs, Aging clinical and experimental research, 2006, 18(6), s.531-535.
19. Mazurek J., Blaszkowska A., Rymaszewska J., Rehabilitacja po udarze mózgu – aktualne wytyczne, Nowiny Lekarskie 2013, 82, 1, s.83-88.
20. Orihuela-Espia F., i wsp., Robot training for hand motor recovery in subacute stroke patients: a randomized controlled trial, Journal of hand therapy, 2016, 29(1), s.51-57.
21. Rosati G., Gallina P., Masiero S., IEE transactions of neural systems and rehabilitation engineering, DEC 2017, 15(1), s. 560-569.
22. Strepikowska A., Buciński A., Udar mózgu – czynniki ryzyka i profilaktyka, Postępy farmakoterapii, 2009, tom 65, nr 1.
23. Szczęsny A. i wsp., Wspomagana rehabilitacja kończyny górnej u chorych po udarze, Przegląd elektrotechniczny, 2021, 4.
24. Villfane J., i wsp., Efficacy of short-term robot-assisted rehabilitation in patients with hand paralysis after stroke: a randomized controlled trail, Surgery Article, 2018, 13(1), s.95-102.
25. Young P., Neuroanatomia kliniczna, pod red. Moryś J., 2016, Edra Urban & Partner.