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The Effects of Kinesiology Treatment on Morphological Characteristics of Top Table Tennis Players with Disabilities

Efectos del Tratamiento de Kinesiología en las Características Morfológicas de los Mejores Jugadores de Tenis de Mesa con Discapacidades

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SUMMARY: Sports results of table tennis players with disabilities depend on the functionality level, but also on morphological characteristics. There is an increased risk of obesity in these athletes with disability due to a reduced level of locomotor functionality. The hitherto practice showed that leading table tennis players with disabilities in Serbia did not have an additional kinesiology treatment implemented as part of their training process, which would encourage both strengthening and flexibility of muscle groups relevant for the efficacy of table tennis game, and reduction of body mass and voluminosity. The goal of this paper is to apply an additional kinesiology treatment and determine its effect of on the morphological characteristics of leading table tennis players with disabilities. Eight representatives, table tennis players with disabilities, both male and female, aged between 23 and 52, were included in the additional kinesiology treatment that lasted for nine months. The measures of longitudinal skeleton dimensionality, body mass and volume, subcutaneous adipose tissue and body mass index were analyzed. In order to establish the effects of kinesiology treatment Student's t-test was used, while the results were processed by means of a statistical package SPSS, version 14.0. The values were estimated at $p < 0.05$ significance level. Male respondents demonstrated statistically significant changes in biceps skinfold ($p = 0.05$). In the case of female respondents no statistically significant difference was observed in anthropometric space. The additional kinesiology treatment indicates a trend towards reduced voluminosity and body mass of both male and female respondents, but not at a statistically significant level, which is probably the result of an insufficient number of respondents. Continued additional kinesiology treatment should be included in the training process of male and female table tennis players with disabilities, which has not been the case up until now.

KEY WORDS: Table tennis; Athletes with disabilities; Anthropometry.

INTRODUCTION

It has been proved that people with disabilities who are engaged in habitual physical activities have manifold benefits, since exercises reduce fatigue, pain, weakness in locomotor apparatus and the initial neurological deficit that accompanies the state of disability (Nash, 2005; Tawashy *et al*., 2009; Duvalla *et al*., 2020). Including people with disabilities in programmed physical activities indirectly and positively influences not only a healthy way of life (Hicks *et al*., 2003; Krahn *et al*., 2015), but kinesiology programs could be used for preventing injuries which might be caused by undesired excessive workout (Ide *et al*., 1994). In the case of people with spinal cord injuries and with a decreased level of locomotor functionality of an organism, there has been an increase in their nourishment level (van Drongelen *et al*., 2006; Back *et al*., 2014). This precisely implies the need to engage people who were diagnosed with the state of reduced functionality upon completed medical rehabilitation in recreational or sports activities in order to adjust their kinetic activity to both medical and sports demands. Table tennis is the most common form of organized physical activity implemented through recreational or sports content, and is particularly popular with the people who sustained spinal cord injuries (paraplegia, quadriplegia) (Taktak, 1997; Caldwell & De Luigi, 2018). As a proof of this, there is a number of countries who participate in the world and European competitions (Solc-Pervan *et al*., 2009), and the possibility of adaptation in a table tennis game, in which people in wheelchairs and those using aids, orthotic and prosthetic devices can participate (International Paralympic Table Tennis Committee, 1992; Caldwell & De Luigi, 2018).

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The success of people with disabilities in sports activities depends primarily on the level of their functionality but also on morphological characteristics. If a training process is not aimed at developing overall physical preparation relevant not only for achievements, but also for their health, certain risks towards an increase in nourishment levels can occur. A training process of table tennis players with disabilities, particularly players in wheelchairs, in our practice (in Serbia) until now has not included kinesiology treatment which would prove the above stated. The players would engage in table tennis with no prior preparations. The training process would start by performing and practicing technique elements and tactics of a table tennis game, overlooking the warm-up of the body with the purpose of elevating the work capacity, exercises to increase range of motion, flexibility, decrease body mass and voluminosity, strengthen muscle groups and develop overall physical fitness. This prompted the authors of the paper to design a suitable kinesiology treatment, categorize it within a hitherto training process of leading table tennis players with disabilities and check its effects. Thus, the aim of the study was to apply the kinesiology treatment and determine its effects on the morphological characteristics of top table tennis players with disabilities.

As far as the recent literature is concerned, such researches on table tennis players with disabilities have not been done neither in our country nor anywhere in the world, which makes it impossible for the authors to provide a more detailed primary literature.

MATERIAL AND METHOD

A pre-experimental draft with a group of respondents was used in the study, in the case of which a pretest posttest was used, i.e. initial measuring treatment and final measuring.

The sample of respondents consisted of eight top table tennis players with disabilities who were classified according to the International Sports Table Tennis Categorization (TT-table tennis), which were divided into sitting (TT1-TT5) and standing classes (TT6-TT11) (Pérez & Lucarevic, 2018; ITTF Classification Rules for ITTF Para Table Tennis, 2018). They are all Serbian representatives, 5 male and 3 female athletes, aged between 23 and 52, the World Cup medal holders (gold, silver, bronze), competing in the TT2 class (level of lesion in the cervical segment C6-C7), TT3 (level of cervical - thoracic segment lesion C8-Th7,8), TT4 (level of thoracic - the lumbar segment lesion Th8-L1,2) and TT7 (serious damage to the lower limbs). Male respondents are with a "complete" spinal cord injury of C6/Th7 level and one respondent is with double amputation of lower limbs of AK/BK level (below/above the knee). The female respondents are with the "complete" spinal cord injury of Th7/L1 level. The parameters of anthropometric indicators were measured according to the International Biological Program (IBP). The protocol was designed according to the Declaration of Helsinki. The respondents were fully informed beforehand about the goals of the research. The used method did not include risks, while the written consent was obtained from each athlete participating in this research.

The variable sample consists of 10 anthropometric measures: body height (BODHEI), body mass (BODMAS), chest circumference (CHCIRC), abdominal circumference (ABDCIR), circumference of a stretched upper arm (CISUPA), circumference of a bent upper arm (CIBUPA), abdominal skinfold (ABDSKF), back skinfold (BACSKF), upper-arm triceps skinfold (UATSKF), upper-arm biceps skinfold (UABSKF), based on which a morphological status was assessed, while one was derived body mass index (BMI), which served as the basis for assessing the nutritional level. All anthropometric measures were expressed in centimeters with the 0.1 cm precision, apart from the body mass which was expressed in kilograms with the 0.1 kg precision. Body mass index represents the relationship between body mass in kilograms and square of height in meters (ITM = kg/m^2). A normal nutritional level ranges between 18.5 and 24.9 kg/m^2, underweight is characterized with the values below 18.5 kg/m^2, while the values between 25 and 29.9 kg/m^2 are classified as overweight.

Anthropometric measures were taken by means of an anthropometric procedure which included the following measuring instruments: the Martin anthropometer, a decimal scale with sliding weights, John Bull calipers and a plastic measuring tape.

Basic central and dispersion parameters were calculated for each anthropometric measure: arithmetic mean (AM), standard deviation (SD), standard error (SE), confidence interval (CI), maximum (MAX) and minimum (MIN) values. Students test at $p < 0.05$ significance level was used to determine the effects of kinesiology treatment on the morphological characteristics of the respondents, while the results were processed using the statistical package SPSS, version 14.0.

The program design of the kinesiology treatment was prepared and conducted in accordance with the contest calendar for 2021, the year when the Paralympic Games was the most important contest, held in Tokyo (Japan). Kinesiology treatment was carried out in the outdoor and

indoor sports facilities in Novi Sad and Banja Kanjiz˘a (Spa Kanjiz˘a, Serbia) and Handlová (Slovakia).

The treatment included strengthening and stretching exercises, upper body balance exercises and was implemented in a regular training process. A complete program of activities was carried out over the course of nine months in three mesocycles. Each cycle lasted for ninety days, and it started off with ten-day conditioning preparations which included solely the program of the kinesiology treatment, 90 - 120 minutes twice a day. Upon the completion of ten-day conditioning preparations of every mesocycle, this treatment was continued and classified within a training process five days a week, twice a day just like in the preparations at the beginning (15 minutes) and at the end of the practice (10 minutes) (McClintock, 2005).

RESULTS AND DISCUSSION

Tables I and II show values of central and dispersion parameters for male and female respondents, obtained through descriptive analysis of anthropometric variablesat the initial measuring.

Based on the calculated values of the relationship between body mass and height (BMI = kg/m^2) at the initial measuring, it was established that the nutritional level is within the normal range considering the age and fitness levels of respondents. The absence of obesity was observed in most respondents, except in the case of respondent with the "complete" spinal cord injury at Th6,7 level, in which case of overweight was recorded (25.6 kg/m^2).

Table I. Descriptive statistics for the initial measurements of male respondents (n=5).

Variables	Anthropometric variables						
	MIN	MAX	AM	SD	SE	CI	
						min	max
BODHEI	172.00	184.40	178.28	4.65	2.07	172.53	184.02
BODMAS	68.00	82.00	74.60	6.15	2.75	6.69	8.22
BMI	20.00	25.60	23.22	3.15	1.72	20.40	24.80
CHCIRC	96.00	107.50	100.90	4.72	2.12	95.04	106.76
ABDCIR	89.00	95.00	91.00	2.35	1.05	88.10	93.92
CISUPA	24.50	33.00	30.00	3.52	1.57	25.63	34.38
CIBUPA	25.50	35.00	31.30	3.82	1.71	26.56	36.04
ABDSKF	7.00	29.00	18.44	7.84	3.50	8.71	28.17
BACSKF	7.40	16.00	12.24	3.28	1.47	8.17	16.31
UATSKF	4.80	7.80	6.26	1.20	0.54	4.77	7.75
UABSKF	3.40	7.20	5.44	1.45	0.65	3.64	7.24

BODHEI body height; BODMAS body mass; BMI body mass index; CHCIRC chest circumference; ABDCIR abdominal circumference; CISUPA circumference of a stretched upper arm; CIBUPA circumference of a bent upper arm; ABDSKF abdominal skinfold; BACSKF back skinfold; UATSKF upper-arm triceps skinfold; UABSKF upper-arm biceps skinfold.

Table II. Descriptive statistics for the initial measurements of female respondents (n=3).

Variables	Anthropometric variables						
	MIN	MAX	AM	SD	SE	CI	
						min	max
BODHEI	167.00	172.00	169.00	2.64	1.53	162.42	175.57
BODMAS	56.00	58.00	57.00	1.00	0.06	5.45	5.95
BMI	18.90	20.80	19.96	2.45	1.02	19.20	20.10
CHCIRC	84.50	92.00	88.67	3.82	2.21	79.20	98.15
ABDCIR	73.00	76.00	75.00	1.73	1.00	70.77	79.30
CISUPA	25.00	28.00	26.33	1.53	0.88	22.54	30.13
CIBUPA	27.00	29.50	28.20	1.26	0.73	25.04	31.32
ABDSKF	11.60	13.00	12.27	0.70	0.41	10.52	14.01
BACSKF	8.00	15.40	11.77	3.38	1.95	3.40	20.20
UATSKF	4.00	10.80	6.27	3.93	2.30	-3.48	16.02
UABSKF	4.00	8.80	5.73	2.66	1.54	-0.88	12.35

BODHEI body height; BODMAS body mass; BMI body mass index; CHCIRC chest circumference; ABDCIR abdominal circumference; CISUPA circumference of a stretched upper arm; CIBUPA circumference of a bent upper arm; ABDSKF abdominal skinfold; BACSKF back skinfold; UATSKF upper-arm triceps skinfold; UABSKF upper-arm biceps skinfold.

In the case of respondent whose level of lesion is that of double amputation of the lower limbs, BMI calculation could not be done since body height was not measured due to asymmetric pylons length. The same respondent was diagnosed with a high risk of metabolic complications based on the circumference measuring 95 cm. The nutritional status of a female respondent with the spinal cord injury at Th7,8 level was said to be at the lowest limit of the normal (18.9 kg/m^2).

Tables III and IV show the values of central and dispersion parameters for both male and female respondents obtained through descriptive analysis of anthropometric variables at the final measuring.

Based on the result values for assessing body mass index (BMI) of both male and female respondents at the final measuring, it was established that the respondents did not belong to the group of overweight people. The nutritional status of the female respondent with the spinal cord injury at the Th7,8 level was observed to be at the lowest limit of the normal (18.6 kg/m^2), while these values among other female respondents remain within the normal range (19.7 kg/m^2 and 20.2 kg/m^2). The identified values of the abdominal circumference variable for male and female respondents are within the normal range. The results regarding the effect of the applied kinesiology treatment on the morphological status of male and female respondents are given in the Table V. A statistically significant difference was observed only in the case of the upper arm skinfold variable biceps (UABSKF), among the male respondents ($p = 0.05$). In other variables which characterize the morphological status of male examinees, the obtained results were not statistically significant. Among female respondents, no statistically significant difference was observed after the treatment in anthropometric space.

Table III. Descriptive statistics for the final measurements of male respondents (n=5).

Variables	Anthropometric variables						
	MIN	MAX	AM	SD	SE	CI	
						min	max
BODHEI	172.00	184.40	178.28	4.65	2.07	172.53	184.02
BODMAS	68.00	80.00	73.80	5.40	2.42	6.70	8.05
BMI	20.00	25.00	23.00	3.10	1.55	20.20	24.50
CHCIRC	94.50	106.50	100.70	4.59	2.05	95.00	106.40
ABDCIR	83.00	98.00	91.00	6.77	3.02	82.60	99.40
CISUPA	23.00	35.00	30.30	4.60	2.06	24.58	36.01
CIBUPA	24.00	36.00	31.80	4.72	2.11	25.93	37.66
ABDSKF	5.80	26.20	15.32	7.94	3.55	5.45	25.18
BACSKF	6.40	14.60	11.08	3.17	1.41	7.13	15.02
UATSKF	4.80	6.80	5.68	0.81	0.36	4.68	6.68
UABSKF	2.20	6.60	4.08	1.68	0.75	2.00	6.17

BODHEI body height; BODMAS body mass; BMI body mass index; CHCIRC chest circumference; ABDCIR abdominal circumference; CISUPA circumference of a stretched upper arm; CIBUPA circumference of a bent upper arm; ABDSKF abdominal skinfold; BACSKF back skinfold; UATSKF upper-arm triceps skinfold; UABSKF upper-arm biceps skinfold.

Table IV. Descriptive statistics for the final measurements of female respondents (n=3).

Variables	Anthropometric variables						
	MIN	MAX	AM	SD	SE	CI	
						min	max
BODHEI	167.00	172.00	169.00	2.64	1.53	162.42	175.57
BODMAS	55.00	57.00	55.66	1.15	0.66	5.27	5.85
BMI	18.60	20.20	19.50	1.85	0.94	18.90	19.80
CHCIRC	83.00	90.00	87.50	3.90	2.25	77.79	97.20
ABDCIR	71.50	78.50	74.66	3.54	2.04	65.85	83.47
CISUPA	25.50	28.00	26.66	1.25	0.73	23.54	29.79
CIBUPA	26.50	30.00	28.00	1.80	1.04	23.52	32.47
ABDSKF	10.20	12.00	11.40	1.04	0.60	8.81	13.98
BACSKF	8.20	12.40	10.45	2.11	1.22	5.20	15.73
UATSKF	4.00	9.40	5.80	3.11	1.80	-1.94	13.54
UABSKF	4.00	7.60	5.20	2.08	1.20	-0.37	10.36

BODHEI body height; BODMAS body mass; BMI body mass index; CHCIRC chest circumference; ABDCIR abdominal circumference; CISUPA circumference of a stretched upper arm; CIBUPA circumference of a bent upper arm; ABDSKF abdominal skinfold; BACSKF back skinfold; UATSKF upper-arm triceps skinfold; UABSKF upper-arm biceps skinfold.

Due to the lack of literature on the effects of additional kinesiology treatment of the morphological status of table tennis players with disabilities, the authors found it appropriate to compare the results of their study with the results of the studies dealing also with the assessment of the morphological status of the athletes and non-athletes with the spinal cord injury, since all but one respondent in this study were those diagnosed with the spinal cord injuries (paraplegia, quadriplegia). The studies consulted were mostly done on non-athletes and are mostly cross-sectional studies, which is why the discussion is divided into two directions. The results of our research at the initial measuring were compared to the results of the given studies. The other part of the discussion refers to the evaluation of the results at the initial and final measurement with respect to the application of the additional kinesiology treatment.

The average height of male respondents in our research (178.28 ± 4.65 cm) is practically identical to the height of non-athletes with disabilities (173 ± 7.1 cm; 176 ± 0.05 cm, 177 ± 0.06 cm, 175 ± 0.1 cm) (Buchholz *et al*., 2003; Dionyssiotis *et al*., 2009). However, the body mass results of the top male table tennis players (74.6 ± 6.15 kg) and that of the respondents from the mentioned researches (71.2 ± 14.6 kg; 81.36 ± 13.0 kg, 76.67 ± 17.12 kg and 76.67 ± 17.12 kg) differ and are in favor of the athletes. Taking into account the results from the final (73.8 ± 5.4 kg) and initial measuring (74.6 ± 6.15 kg), of body masses of the respondents in our study, it may be established that having undergone the kinesiology treatment the respondents had lower average values, which were not significantly different. If we compare the results regarding body height (169.0 ± 2.64 cm) and body mass (57.0 ± 1.0 kg) of our female respondents with the results of female non-athletes from other studies (height 154.0 ± 10.6 cm, body mass 57.5 ± 14.2 kg) (Buchholz *et al*., 2003), (body height 172.0 ± 5.7 cm, 165.5 ± 10.8 cm and body mass 55.0 ± 7.8 kg, 57.3 ± 9.7 kg) (Schmid *et al*., 2008) different values can be observed indicating the fact that female table tennis players have uniform body mass values, which probably results from being engaged in sport activities.

At the final measurement, female, as well as male respondents had lower body mass values which were not statistically significant, but based on the nominal values, there is an evident trend towards the improvement of results for all the variables of anthropometric space in favor of the final measurement.

The results of the study which was carried out on basketball players, athletes and tennis players with disabilities and which deals with the assessment of total and segmental body composition also includes the results of longitudinal skeleton dimensionality, body mass and voluminosity obtained through a standard anthropometric procedure and derived BMI (Inukai *et al*., 2006). The results of our research at the initial measurement for male respondents referring to the assessment of the BMI (23.22 ± 3.15 kg/m^2), chest circumference (100.90 ± 4.72 cm), abdominal circumference (91.0 ± 2.35 cm) and an extended upper-arm circumference (30.0 ± 3.52 cm) are consistent with the results of the study mentioned (BMI: basketball players 23.1 ± 3.7 kg/m^2, athletes 23.0 ± 2.8 kg/m^2 and tennis players 23.6 ± 5.3 kg/m^2; chest circumference: basketball players 100.3 ± 11.8 cm, athletes 100.9 ± 7.4 cm and tennis players 98.9 ± 17.0 cm; abdominal circumference: basketball players 81.4 ± 6.9 cm, athletes 79.4 ± 5.1cm and tennis players 82.3 ± 7.1 cm; a left extended upper-arm circumference: basketball players 32.7 ± 2.7 cm, athletes 32.0 ± 2.1 cm and tennis players 32.8 ±3.8 cm). A difference was observed with respect to the abdominal circumference in favor of our respondents, while the difference in chest circumference and

Table V. The effects of applying the additional kinesiology treatment on the morphological status of both male and female respondents.

Variables	Sex									
	M					F				
	AM	SD	t	df	p	AM	SD	t	df	p
BODMAS	0.80	0.84	2.14	4	0.099	1.33	1.52	1.51	2	0.270
CHCIRC	2.00	22.00	0.20	4	0.849	11.66	15.27	1.32	2	0.317
ABDCIR	0.00	60.31	0.00	4	1.000	3.33	24.66	0.23	2	0.837
CISUPA	-3.00	12.55	-0.54	4	0.621	-3.33	10.40	-0.55	2	0.635
CIBUPA	-5.00	12.74	-0.88	4	0.430	1.66	11.54	0.25	2	0.826
ABDSKF	31.20	31.3	2.23	4	0.089	8.66	6.11	2.45	2	0.133
BACSKF	11.60	11.10	2.34	4	0.079	13.00	14.73	1.52	2	0.266
UATSKF	5.8	5.02	2.58	4	0.061	4.66	8.08	1.00	2	0.423
UABSKF	13.6	5.55	5.48	4	0.050	5.33	6.11	1.51	2	0.270

BODMAS body mass; CHCIRC chest circumference; ABDCIR abdominal circumference; CISUPA circumference of a stretched upper arm; CIBUPA circumference of a bent upper arm; ABDSKF abdominal skinfold; BACSKF back skinfold; UATSKF upper-arm triceps skinfold; UABSKF upper-arm biceps skinfold. $p < 0.05$ statistical significance

an extended upper-arm circumference was in favor of the respondent of the given study. This can be accounted for by a different structure of sport activities where the work of upper body muscles and those of the upper limbs is consistent with the demands of technique elements in sports activities.

None of the variables for assessing circumference and skinfolds (except for UABSKF among male respondents) of the respondents of both sexes showed a statistically significant difference. The difference in the nominal values recorded between the initial and final measurement with respect to the application of the additional kinesiology treatment is in favor of the results obtained at the final measurement.

CONCLUSION

Based on the results of the analysis of the morphological status of the leading table tennis players with disabilities, there is evident improvement of all the nominal values upon completion of the additional kinesiology treatment, with the exception of UABSKF variable, among the male respondents, where a statistically significant difference was observed ($p < 0.05$). The results obtained this way can be affected by a small number of respondents, but also by an insufficiently long application of the kinesiology treatment. In other variables the differences are not statistically significant, but the positive trend of the obtained results between the initial and final measurement implies the need to introduce the additional kinesiology treatment into regular training activities of the top table tennis players with disabilities, which is supposed to become a compulsory segment of the training process of this population of athletes. The lack of research related to the table tennis players with disabilities triggers the need for researchers to engage more into the problems of the morphological status which can have impact on all the segments of the training process of this population.

ROMANOV, R.; STUPAR, D. & MEDJEDOVIC, B. Efectos del tratamiento de kinesiología en las características morfológicas de los mejores jugadores de tenis de mesa con discapacidades. *Int. J. Morphol., 40(4)*:939-945, 2022.

RESUMEN: Los resultados deportivos de los jugadores de tenis de mesa con discapacidad dependen del nivel de funcionalidad, pero también de las características morfológicas. Existe un mayor riesgo de obesidad en estos atletas con discapacidad debido a un nivel reducido de funcionalidad locomotora. La práctica hasta ahora mostró que los principales jugadores de tenis de mesa con discapacidades en Serbia no cuentan con un tratamiento de kinesiología adicional, implementado como parte de su proceso de entrenamiento, que fomentaría tanto el fortalecimiento como la flexibilidad de los grupos musculares relevantes para el juego de tenis de mesa, y la reducción de masa corporal y voluminosidad. El objetivo de este trabajo fue aplicar un tratamiento kinesiológico adicional y determinar su efecto sobre las características morfológicas de los principales jugadores de tenis de mesa con discapacidad. Ocho representantes, jugadores de tenis de mesa con discapacidad, tanto hombres como mujeres, con edades entre 23 y 52 años, fueron incluidos en el tratamiento adicional de kinesiología que tuvo una duración de nueve meses. Se analizaron las medidas de dimensionalidad esquelética longitudinal, masa y volumen corporal, tejido adiposo subcutáneo e índice de masa corporal. Para establecer los efectos del tratamiento kinesiológico se utilizó la prueba t de Student, mientras que los resultados se procesaron mediante el paquete estadístico SPSS, versión 14.0. Los valores se estimaron a un nivel de significación $p < 0,05$. Los hombres encuestados demostraron cambios estadísticamente significativos en el pliegue cutáneo del bíceps ($p = 0,05$). En el caso de las mujeres encuestadas no se observó diferencia estadísticamente significativa en el espacio antropométrico. El tratamiento de kinesiología adicional indica una tendencia hacia la reducción de la voluminosidad y la masa corporal de los encuestados masculinos y femeninos, pero no a un nivel estadísticamente significativo, lo que probablemente sea el resultado de un menor número de encuestados. El tratamiento kinesiológico continuo debe incluirse en el proceso de formación de los jugadores de tenis de mesa con discapacidad, lo que no ha sido el caso hasta el momento.

PALABRAS CLAVE: Tenis de mesa; Deportistas con discapacidad; Antropometría.

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