SHARE OF STRENGTH PARAMETERS OF BENCH PRESS AND BARBELL BENCH PULL ON A HORIZONTAL BENCH IN SPORTS PERFORMANCE IN KAYAK DISCIPLINES

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Abstract
The objective of the study was to deal with the ratio of the parameters of maximum muscle power and power endurance and explain their contribution to the sports performance in kayak disciplines of Slovakia National Team members.

Material and methods. Strength parameters were monitored by Tendo Power Analyser in the barbell bench press and pull on a horizontal bench. A diagnostic series of maximum power and effective repetition test for power endurance was performed at both, barbell bench press and bench pull exercises. Determining the factors limiting sports performance in kayak disciplines 200 meters, 500 meters, 1,000 meters, 5,000 meters, and marathon 21,500 meters, the evaluation of dependence between all power variables were used. The stepwise regression was used to reduce the indicators.

Results. It was found out that in kayak sprint disciplines (200 meters, 500 meters) the sports performance in the kayak is influenced by the barbell bench pull more than bench press on the horizontal bench when speaking about the strength parameters. In the middle-distance disciplines (1,000 meters), the ratio of strength parameters is balanced. As the length of kayak disciplines increases (5,000 meters and 21,500 meters), the ratio of strength parameters has changed in favor of the barbell bench press.

From the parameters of maximum muscle performance and muscle endurance measured in the barbell bench press and pull on a horizontal bench, the average power of power endurance was demonstrated to explain the sports performance in kayak disciplines.

Conclusion. From the parameters of maximum power and power endurance in the bench press and bench pull in all kayak disciplines, the parameter of average power in power endurance was proved to explain sports performance.

Knowledge of these factors will allow optimizing the content of sports training of kayakers, the process of developing their strength skills, and their transformation process into a structure of sports performance and kayaking paddling technique.

Keywords: sports performance, kayak disciplines, stepwise regression, National Sports Center

Introduction
Sports disciplines in kayaking and canoeing are gaining more and more popularity (Ăkca & Muniruglu, 2008). Canoe Sprint is a traditional Olympic sport (Bielik et al., 2019) that belongs to one of the most successful sports in Slovakia and the Czech Republic, as evidenced by many gold, silver, and bronze medals from international competitions, Olympic Games, World Championships and Europe (McKean & Burkett, 2014). It is a water sport performed on calm stagnant or slightly flowing waters, whether they are natural or artificial (Plagenhoef, 1979). The goal is to overcome with the boat the distance in the shortest possible time. Races can be on two types of boats, first is canoe which is divided to C1, C2, C4 (depending on the number of competitors on the boat), and the second is the kayak which is divided to K1, K2, K4 (Schmidt, 1992; Doktor, 2001; Barton, 2002). In a canoe, the paddler kneels and uses a single-bladed paddle to propel the boat forward and in the kayak, the paddler is seated and uses a double-bladed paddle pulling the blade through the water on alternate sides to move forward (Baker, Rath, Sanders, Kelly, 1999; Sendelbeck & Schmid, 2016). Sprint canoe is the strength-endurance type of sport; however, this does not mean that it depends only on the strength and endurance abilities of the individual which fall into conditioning factors affecting sports performance (Lopata, 2014). In modern elite sports nowadays identification of the best training methods
is used, which is useful for improving strategies during com-
petitions. Such a strategy requires accurate measurements of
 biomechanical and physiological parameters affecting sports
 performance (Kendal, Sanders, 1992). Due to constant pad-
dling, kayaking is considered demanding muscular activity
 consisting of cyclic and acyclic uneven movements (Ste-
cenko, 1982, Vieira et al., 2015). Paddling requires proper
 technique and coordination of movement and muscles so
 that movement is economical and only the muscles neces-
sary during paddling are involved (Bauer, 1988; Gagin, 1981).
 When paddling, the strength of the upper limbs is used, but
 the lower part of the body also contributes. Paddling itself
 can be further characterized as forward-pressure movements
 and backward-pulling movements (Borkovcová, 2005; Ja-
nura, Kratochvíl, Lehner & Veverka, 2005). In kayaking, we
distinguish disciplines of 200 m, 500 m, 1000 m, 5000 m,
 and marathon 21500 m (Grigorjev, Krasnopecev, 1972). Seating
 and support of the boat differ according to the discipline.

The objective of the study was to find the rate of the pro-
portion of strength parameters measured in bench press and
 bench pull on the horizontal bench on explaining the sports
 performance in the kayak disciplines at 200 meters, 500 me-
ters, 1000 meters, 5000 meters, and in the marathon 21500
 meters. It was assumed, based on the previous studies, that
 the indicator of the average power of power endurance in
 the bench press will contribute the most to the explanation of
 sports performance in the kayak disciplines.

Material and methods

Study participants
The research sample consisted of representatives of the
 Slovak republic in kayaking N= 17, with average age M =
 16.82 years SD = 0.89. The average body height of sample was
 M = 175.44 cm, SD = 23.19 and average body weight M =
 84.62 kg, SD = 27.57 kg.

Study organization
The level of physical development, strength parameters,
 and sports performance is characterized by mean (M), stand-
ard deviation (SD), minimum (Min), maximum (Max) in
 Tables 1 and 2. The measurement of strength parameters took
 place in the Slovak National Sports Center. The best results in
 the kayak disciplines of 2019 were obtained from the docu-
 ments of the Slovak Canoe Association.

Bench press and bench pull strength parameters were
 measured by the Tendo power analyzer. Tendo power ana-
 lyzer measures average power and velocity, partial average
 power, peak power, velocity and force, eccentric average ve-
locity, and rest time between reps or sets. In bench press and
 bench pull were performed diagnostic series of maximum
 power (weight of the barbell and average power) and test of
effective repetitions for the power endurance (weight of the
 barbell, average power, number of repetitions). The weight of
 the barbell was the same in the bench press and bench pull.

Statistical analysis
When defining the limiting factors of sports perfor-
 mance in kayak discipline, the base is on the evaluation of
 dependence between every strength parameter. Step regres-
sion analysis was used for the reduction of indicators and
 the elimination of multicollinearity. This technique has used
 the method Backward, which is characterized by the gradual
 separation of variables from the total set in the regression
 function. These are back-tested to see if they statistically af-
flect the quality of the regression model. Dependency (Pear-son correlation coefficient r) and share (beta*r) of individual
 factors were determined by the correlation and regression
 analysis. From the regression parameters, we present the de-
terminant of multiple correlation (R2) and the significance
 of the model (F). Effect size is measured by Cohen’s d and
 f2 (Cohen, 1998). Statistical significance is assessed on two
 significance levels p<0.05 and p<0.01 and effect size on 0.02 =
 small; 0.15 = medium; 0.35 = large effect. Empirical data were
 processed and evaluated in MS Excel and SPSS.

Results
When verifying the hypothesis, it was assumed that the
 indicator of the average power on the bench will contribute
 most to the explanation of sports performance in kayak dis-
cipline on 200 meters, 500 meters, 1000 meters 5000 meters
 and in marathon 21500 meters. To verify this hypothesis, tech-
nique of correlation, regression, and step analysis were used.

By the correlation analysis between parameters of
 strength in bench press and bench pull on the horizontal
 bench with the sports performance, the interactions were
 proven to a minimal extent. The strength parameters of the

Table 2 Sports performance of the monitored group in
 kayak disciplines

| Kayak disciplines | M   | SD  | Max  | Min  |
|------------------|-----|-----|------|------|
| 200 m [s]        | 41.12 | 1.74 | 43.87 | 38.16 |
| 500 m [min]      | 1:55.28 | 0.0357 | 2:01.84 | 1:48.96 |
| 1000 m [min]     | 4:04.93 | 0.0488 | 4:12.55 | 3:58.00 |
| 5000 m [min]     | 23:04.15 | 0.58.52 | 25:39.30 | 21:50.03 |
| 21500 m [h]      | 1:47.28 | 0.05:19 | 1:55.01 | 1:40:48 |

Table 1 Comparison of the level of strength parameters in bench press and bench pull on the horizontal bench

| Tendo Power Analyzer | Bench press | Bench pull | t-test | p  | d   |
|----------------------|-------------|------------|--------|----|-----|
| Maximum barbell weight [kg] | 58.235 | 5.847 | 61.471 | 6.063 | 2.184 | 0.044 | 0.543 |
| Average power [W] | 538.647 | 55.913 | 654.118 | 76.587 | 9.608 | 0.000 | 1.722 |
| Power endurance | 58.235 | 5.847 | 61.176 | 6.002 | 2.184 | 0.044 | 0.543 |
| Average power [W] | 486.294 | 39.352 | 571.873 | 57.952 | 7.491 | 0.000 | 1.728 |
| Repetitions [n] | 8.176 | 2.378 | 6.941 | 3.132 | 1.558 | 0.139 | 0.444 |
bench press did not show any statistically significant relations with sports performance in any kayak discipline. From the bench pull parameters on the horizontal bench were statistically significant interactions of the average power of power endurance (W) to the sprint disciplines on 200 m $r(17) = -0.505; p < 0.05$ and to 500 m $r(17) = -0.493, p < 0.05$. Other remaining interactions between the strength parameters and sports performance were not statistically significant (Tab. 3).

Another technique used to determine the proportions of factors limiting sports performance was the multiple regression analysis of all strength parameters individually in bench press and bench pull on the horizontal bench. The multiples of the beta correlation coefficients and the correlation coefficients $r$ were calculated the partial shares (Tab. 4) to the sports performance. The highest contribution to the explanation of sports performance in the discipline of kayaking at 200 meters has the bench pull (38%) before the bench press (10.1%). From the parameters of power endurance in bench pull are important parameters of the average power 25.3%, the number of repetitions 7.7%, and maximum power 5.2%.

Same in 500 meters kayaking, the bench pull (30.9%) is over that bench press (25.0%). From the bench pull parameters, it is represented by power endurance (19.4%) and by numbers of repetitions (11.1%). In the bench press, key parameters are the weight of the barbell (11.5%), maximum power (6.4%), and average power (6.8%). The share of strength parameters in 1000 meters kayaking is similar (12.0% and 11.8%). In both cases “press vs. pull” are key parameters of the weight of the barbell (7.1% and 5.0%), numbers of repetitions (3.9% and 3.3%), and average power in the power endurance (1.1% and 3.1%). As the length of the kayak disciplines increases, the proportion of strength parameters changes in favor of the strength parameters at the bench press over the bench pull (5000 meters: 17.9% <> 5.5%; 21500 m: 36.6% <> 1.3%). In the discipline of 5000 meters kayaking, key parameters are the average power endurance (11.3%) and maximum power performance (5.9%). In marathon discipline (215000 meters) are important parameters of barbell weight (17.6%) and average maximum power (14.5%). It shows that in the sprint disciplines of kayaking (200 meters and 500 meters) the highest share on the sports performance has the strength parameters in bench pull before the bench press on the horizontal bench. In the medium distances (1000 meters) is the share of bench press and bench pull parameters equal. As the length of the kayak disciplines increases (5000 meters and 21500 meters), the proportion of strength parameters changes in favor of parameters of strength in the bench press.

When identification of limiting factors of sports performance in kayak disciplines, the reduction of indicators of all strength parameters individually in bench press and bench pull on a horizontal bench are used. For the reduction of indicators, the stepwise regression analysis was used. Mostly in all kayak disciplines, the parameter of average power in power endurance (Tab. 5) in the bench press and bench pull has the greatest information power.

In the complex reduction of strength parameters in the bench press and bench pull, the previous findings have been confirmed. In sprint disciplines, the parameters of bench pull

Table 3. Correlations of strength parameters in bench press and bench pull on horizontal bench with the sports performance in kayak disciplines ($p < 0.05$; $p < 0.01$)

| Indicator | 200 m | 500 m | 1000 m | 5000 m | 21500 m |
|-----------|-------|-------|--------|--------|---------|
| Barbell weight [kg] | -0.166 | -0.345 | -0.200 | -0.011 | -0.374 |
| Average power [W] | -0.141 | -0.250 | -0.043 | 0.143 | 0.351 |
| Maximum power | -0.166 | -0.345 | -0.200 | -0.011 | -0.374 |
| Average power [W] | -0.301 | -0.401 | -0.160 | 0.255 | -0.218 |
| Maximum power | -0.220 | -0.021 | -0.223 | 0.110 | -0.117 |
| Barbell weight [kg] | -0.106 | -0.230 | 0.118 | -0.164 | -0.067 |
| Average power [W] | -0.211 | -0.186 | -0.059 | -0.038 | -0.234 |
| Repetitions [n] | -0.034 | -0.188 | 0.142 | -0.029 | -0.023 |
| Maximum power | -0.034 | -0.188 | 0.142 | -0.029 | -0.023 |
| Average power [W] | -0.211 | -0.186 | -0.059 | -0.038 | -0.234 |
| Repetitions [n] | -0.034 | -0.188 | 0.142 | -0.029 | -0.023 |

Table 4. Partial shares of strength parameters in bench press and bench pull on horizontal bench on the sports performance in kayak disciplines ($\beta \times r$)

| Indicator | Maximum power | Power endurance |
|-----------|---------------|-----------------|
| Barbell weight [kg] | Average power [W] | Average power [W] | Repetitions [n] | $R^2$ |
| 200 m Bench Press | 0.033 | -0.007 | 0.002 | 0.072 | 0.101 |
| 200 m Bench Pull | -0.002 | 0.052 | 0.253 | 0.077 | 0.308 |
| 500 m Bench Press | 0.115 | 0.064 | 0.068 | 0.003 | 0.250 |
| 500 m Bench Pull | 0.005 | -0.002 | 0.194 | 0.111 | 0.309 |
| 1000 m Bench Press | 0.071 | 0.000 | 0.011 | 0.039 | 0.120 |
| 1000 m Bench Pull | 0.050 | 0.004 | 0.031 | 0.033 | 0.118 |
| 5000 m Bench Press | 0.000 | 0.059 | 0.113 | 0.007 | 0.179 |
| 5000 m Bench Pull | 0.001 | 0.013 | 0.019 | 0.022 | 0.055 |
| 21500 m Bench Press | 0.176 | 0.145 | 0.027 | 0.014 | 0.363 |
| 21500 m Bench Pull | -0.004 | -0.019 | 0.036 | 0.000 | 0.013 |
Table 5. Step regression of strength parameters in bench press and bench pull to sports performance in kayak disciplines (β^*r*)

| Indicator | Maximum power | Power endurance |
|-----------|---------------|-----------------|
|           | Barbell weight | Average power | Barbell weight | Average power | Repetitions | F    | sig | R^2 | F^* |
| 200 m     | Bench Press   | -0.028         | -0.090         | -0.405        | 1.499      | 0.240 | 0.091 | 0.100 |
|           | Bench Pull    | -             | -0.209         | -0.154        | 2.871      | 0.111 | 0.161 | 0.191 |
| 500 m     | Bench Press   | -             | -0.065         | -0.039        | 0.785      | 0.390 | 0.050 | 0.052 |
|           | Bench Pull    | -             | -0.116         | -0.017        | 0.601      | 0.450 | 0.039 | 0.040 |
| 1000 m    | Bench Press   | -             | 0.147          | -0.053        | 2.444      | 0.139 | 0.140 | 0.163 |
| 5000 m    | Bench Press   | 0.140          | -              | -0.053        | 2.444      | 0.139 | 0.140 | 0.163 |

Table 6. Step regression of all strength parameters to sports performance in kayak disciplines (β^*r*)

| Indicator | Maximum power | Power endurance |
|-----------|---------------|-----------------|
|           | Barbell weight | Average power | Barbell weight | Average power | Repetitions | F    | Sig | R^2 | F^* |
| 200 m     | Bench Press   | -0.020         | 0.405          | 0.141         | 4.789      | 0.018 | 0.525 | 1.105 |
|           | Bench Pull    | -             | 0.243          | -             | 4.823      | 0.044 | 0.243 | 0.322 |
| 500 m     | Bench Pull    | -             | -0.045         | -0.104        | 0.707      | 0.414 | 0.045 | 0.047 |
| 1000 m    | Bench Pull    | -             | 0.065          | -             | 1.043      | 0.323 | 0.065 | 0.070 |
| 21500 m   | Bench Press   | 0.140          | -              | -             | 2.444      | 0.139 | 0.140 | 0.163 |

are statistically significant. In the endurance disciplines, the parameters of the bench press proved to be statistically significant. In 200 meters, the greatest share on the sports performance has the average power (40.5%) and the numbers of repetitions in the power endurance (14.1%). A high share of average power in power endurance (24.3%) is recorded in 500 meters kayaking discipline. The significance of parameters to the sports performance was confirmed in both cases statistically (p < 0.05) with the effect size f^2 > 0.3. In endurance kayak disciplines, the results are ambiguous according to their statistical significance. A factor of effective repetitions in power endurance in bench pull (4.5%) was measured in 1000 meters kayaking. The bench press is the limiting factor in the endurance kayak disciplines in 5000 meters (average power in power endurance 6.5%) and in 21500 meters (barbell weight 14.0%).

Discussion

This study aimed to compare the strength parameters measured in bench press and bench pull in the horizontal bench on the explanation of the sports performance in kayak disciplines in 200 meters, 500 meters, 1000 meters, 1000 meters, and in marathon 21500 meters (Endicott, 1995; Potočný, 1985). Data were recorded through the Tendo power analyzer. This study shows that the percentage of average power in power endurance (Strnadová, 2004) in the bench press and bench pull, has a great impact on the sports performance in kayak disciplines. Interactions of sports performance and strength parameters in the bench press did not prove to be statistically significant. Interactions of sports performance and strength parameters in bench pull were significant in the average power of power endurance in 200 meters and 500 meters. Sports performance partial shares in kayak disciplines determine limiting factors. In the discipline of 200 meters, have the highest share on the sports performance the bench pull parameters (power endurance in average power, numbers of repetitions, and maximum power). Similarly, in the 500 meters discipline the bench pull was a key determinant in parameters of power endurance and numbers of repetitions. In the bench press, the important determinants were the barbell weight, maximum power, and average power (Bílý et al., 2000). In the 1000 meters discipline, the parameters of barbell weight, numbers of repetitions, and average power in power endurance prevailed. The share of strength parameters in the bench press and bench pull is equal (Joachimshalter, 1967; Rodano, Squadrone, Sachchi, & Marzegan, 2001). The average power endurance and maximum power in the bench press were key determinants in 5000 meters long discipline. In kayaking marathon (21500 meters) prevailed parameters of barbell weight and average maximum power measured in the bench press (Janura, Kubu, Kratochvill & Stromšík, 2000). According to continuous measurements, performance in the kayak discipline is greatly influenced by the technique (Bauer, 1988; Fučíková, 2003). According to Janura et al. (2000), an effective technique can be described as a symmetrical range of movement of both hands, minimal torso movement in the anteroposterior direction, and greater arm rotation, which author calls mechanical skill. Doktor (2001) and Schmidt analyze in their work the paddling techniques. Strnadová (2004) discussed the importance of muscle involvement. On the sports performance in sprint kayak disciplines (200 meters and 500 meters) the strength parameters in bench pull on the horizontal bench are statistically important (Szanto, 1991, 2004; Šebesta & Podlucký, 2002). The proportion of power in the bench press and bench power is balanced in the medium distance discipline (1000 meters). With the increasing length of kayak disciplines (5000 meters...
and 21500 meters), the proportion of strength parameters varies in favor of power in the bench pull (Sanders, 1998).

Conclusion

The used approach allowed pay attention to the strength parameters, which provide the essential information to an explanation of sports performance in kayak disciplines. It shows that in the sprint disciplines (200 meters and 500 meters) has a greater impact on the sports performance strength parameters measured in bench pull than in the bench press. In middle distance discipline (1000 meters) the share of power in bench press and bench pull is balanced. With the increasing length of kayak discipline (5000 meters and 21500 meters), the proportion of strength parameters varies in favor of power in the bench press. From the parameters of maximum power and power endurance in bench press and bench pull in all kayak disciplines the parameter of average power in power endurance was proved to explain sports performance. Knowledge of these factors will allow optimizing the content of sports training of kayakers, the process of developing their strength skills, and their transformation process into a structure of sports performance and kayaking paddling technique.

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Conflict of Interest

The authors declare that there is no conflict of interest.

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ЧАСТКА СИЛОВИХ ПАРАМЕТРІВ ЖИМУ ЛЕЖАЧИ ТА ТЯГИ ШТАНГИ НА ГОРИЗОНТАЛЬНІЙ ЛАВІ У СПОРТИВНИХ ПОКАЗНИКАХ У ДИСЦИПЛІНАХ ВЕСЛУВАННЯ НА БАЙДАРКАХ

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Reферат. Стаття: 6 с., 6 табл., 31 джерело.

Метою дослідження було розглянути співвідношення параметрів максимальної м’язової сили та силової витривалості та пояснити їхній внесок у спортивні показники у дисциплінах веслування на байдарках членів національної збірної Словаччини.

Матеріал і методи. Силові параметри контролювали за допомогою Tendo Power Analyzer у жимі штанги та тягі на горизонтальній лаві. Діагностична серія тестів максимальної потужності і ефективних повторень на силову витривалість була проведена як у вправах на жим штанги лежачи, так і у вправах на тягу лежачи. Для визначення факторів, що обмежують спортивні показники в дисциплінах веслування на байдарках 200 м, 500 м, 1000 м, 5000 м та марафоні 21 500 м, використовували оцінку залежності між усіма силовими змінними. Для зменшення показників використовувалося покрокова регресія.

Результати. Було виявлено, що у дисциплінах спринтерського веслування на байдарках (200 м, 500 м) на спортивній показники впливає тільки штанга більше, ніж жим штанги на горизонтальній лаві. У дисциплінах на середній дистанції (1000 м) співвідношення параметрів сили вважене. Зі збільшенням довжини дисциплін у веслуванні на байдарках (5000 м та 21 500 м) співвідношення параметрів сили змінилося на користь жиму штанги.

На основі параметрів максимальної м’язової продуктивності та м’язової витривалості, виміряних у жимі штанги та тягі на горизонтальній лаві, була використана середня потужність силової витривалості для пояснення спортивних результатів у дисциплінах веслування на байдарках.

Висновки. Аналіз показників максимальної потужності та силової витривалості в жимі лежачи та тягі лежачи дозволяє, що у всіх дисциплінах веслування на байдарках параметер середньої потужності у силовій витривалості пояснює спортивні результати. Знання цих чинників дозволяє оптимізувати зміст спортивної підготовки байдарочників, процес розвитку їх силових здібностей та процес їх трансформацію в структурі спортивної діяльності та техніку веслування на байдарках.

Ключові слова: спортивні показники, дисципліни веслування на байдарках, покрокова регресія, Національний спортивний центр

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