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MORPHOLOGIC CHARACTERISTICS OF ROWERS, SWIMMERS, ALPINE SKIERS, AND SKI JUMPERS

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Abstract: *The best Slovene sportsmen, members of national senior teams in rowing (6), swimming (6), alpine skiing (8) and ski jumping (8) were investigated. As a reference group, 300 most successful 14 - 16.5 year old players of basketball, volleyball and soccer were also measured. We computed and plotted the characteristics of the body profiles, profiles of body composition, body skin surface area, muscular-bone indices and morphologic somatoypes according to Heath-Carter.*

Keywords: *Body dimensions; Body composition; Muscular-bone indices; Somatotypes; Rowers; Swimmers; Alpine skiers; Ski jumpers.*

Introduction

The shape of a sportsman's body is the final manifestation of the interaction of genetic disposition in logical functional relation to a particular sportsman's work abilities, which are again a manifestation of the interaction between genetic disposition and environmental factors. The various morphologic characteristics of the locomotor apparatus are closely related to motor abilities of an individual and vice versa.

In sportsmen, a particular physical activity affects the adaptation range of the functional capacity of the organic systems which are involved in providing oxygen to muscle cells, and directs over them energy to those muscle groups which are most actively engaged in a particular branch of sport. Since the sportsmen selected herein were engaged in sport already in puberty, it can be assumed that a certain physical activity affected more significantly the development of some morphologic aspects of the locomotor system, and was thus involved in the formation of a specific pattern of the development of genetic potentials of an individual, which represents the first stage in the development of deeper differences between sportsmen in later age periods.

Materials and methods

In order to establish some anthropometric characteristics in sportsmen in the sports selected, their body profiles, somatotypes and body composition, we carried out measurements on the best Slovene rowers, alpine skiers, ski jumpers and swimmers. The measurements were performed in autumn, 1989, and in spring, 1990 (Table 1).

In addition, we also used the results of the measurements carried out on our best, worldwide-established individuals which in world championships ranked from the first to the third place (R.K. and M.J.: coxless pair; B.P.: 1500-m-crawl; B.K.: slalom and giant slalom; and P.U.: ski jumps (Table 2).

Table 1: The main characteristics of the sportsmen groups

	Rowers	Swimmers	Alpine skiers	Ski jumpers
Number	6	6	8	8
Age	22.6	19.5	22.4	23.3
Body height (cm)	188 ± 4.1	183 ± 6.3	179 ± 7.0	179 ± 5.2
Body mass (kg)	83.8 ± 4.2	79.6 ± 8.7	79.1 ± 7.8	67.9 ± 5.6
Body fat (%)	7.17 ± 1.9	8.04 ± 1.6	8.49 ± 1.7	6.4 ± 1.1

Table 2: The main characteristics of Slovene worldwide established individuals in each sport

	Rowers (R.K.+M.J.)	Swimmer B.P.	Alpine skier B.K.	Ski jumper P.U.
Age (years)	25	20	25	27
Body height (cm)	191	184	167	177
Body mass (kg)	85.0	93.0	70.1	62.9
Body fat (%)	6.4	16.0	7.1	7.2

As a reference group, 300 most successful players of basketball, volleyball and soccer in the age between 14 and 16,5 years were measured (in 1985/86) (Table 3). We have taken 15 years old most successfull athletes in ball games as a reference group because they were almost as active as were the studied groups in the same development period. Sports training in this period primarily fascilitates manifestation of latent motor abilities on the individuals physical development because one of the important factors affecting this development of the skeleton are physical activities in which sportsmen overcomes his own body mass.

Table 3: The main characteristics of the reference group (basketball, volleyball and soccer players)

Number	300
Age	15.1 ± 0.6
Body height (cm)	177 ± 7.0
Body mass (kg)	65.0 ± 7.6
Body fat (%)	8.4 ± 1.7

Sample of Variables:

Anthropometric measurements: height; body mass; circumferences (upper arm - relax, upper arm - contract, forearm, thigh, calf; diameters (humerus, wrist, femur, ankle); biacromial diameter; biiliocristal diameter; skinfolds (of triceps, of biceps, of arm, subcapsular, of chest, abdominal, suprailiacal, of thigh, of calf).

Computed values:

1. The body dimensions: we computed Z values of each anthropometric variables according to reference group by formula of Ross and Wilson (1974) (in: Eiben and Csébfalvi 1977);

2. Body composition: • % of body fat (Lohman 1981, Jackson and Pollock 1976, Jackson et al. 1978, Matiegka 1933, in: Sušnik 1984) • % of bone mass (Matiegka 1933, in: Sušnik 1984) • % of muscular mass (Matiegka 1933, in: Sušnik 1984);

3. Muscular and bone indices

$$BS = 0.01672 \times \sqrt{\text{body height(cm)}} \times \sqrt{\text{body mass(kg)}}$$

BS .... body surface area (Jović et al., 1983)

Lean circumferences: (Bravničar, 1982)

$$\text{Lean upper arm circum.} = \left[\frac{\text{upper arm circum.}}{2\pi} - \frac{(\text{biceps skinfold} + \text{triceps skinfold})}{4}\right] \times 2\pi$$

$$\text{Lean thigh circum.} = \left[\frac{\text{thigh circum.}}{2\pi} - \frac{\text{thigh skinfold}}{2}\right] \times 2\pi$$

$$\text{Lean calf circum.} = \left[\frac{\text{calf circum.}}{2\pi} - \frac{\text{calf skinfold}}{2}\right] \times 2\pi$$

Muscular-bone indices of upper extremities: (Bravničar, 1982)

$$\text{MBI 1} = \frac{\text{upper arm circ. contr. - upper arm circ. relax}}{\text{diameter of humerus}}$$

$$\text{MBI 2} = \frac{\text{upper arm circum.}}{\text{diameter of humerus}}$$

$$\text{MBI 3} = \frac{\text{forearm circum.}}{\text{diameter of humerus}}$$

Muscular-bone indices of legs:

$$\text{MBI 4} = \frac{\text{thigh circum.}}{\text{diameter of femur}}$$

$$\text{MBI 5} = \frac{\text{calf circum.}}{\text{diameter of femur}}$$

$$\text{Trunk index (INTR)} = \frac{\text{biacromial diameter}}{\text{biiliocristal diameter}};$$

4. Anthropometric somatotypes were determined according to the Heath-Carter anthropometric method (Duquet et al. 1977).

We used descriptive statistics and calculated Z-values for each variable for the best represantives in each sport and for the groups. A oneway ANOVA was used to assess significant differences between the sportsmen groups.

Results and discussion

Body dimensions. From Figure 1 and 2 it may be concluded that natural selection and the effects of training produce in alpine skiers changes above all on the bones of the lower extremities. There are two factors affecting this development: the first one are large static and explosive loads requiring that a strong, explosive musculature with large cross-sections develops - which in turn requires a firm and robust skeleton and joints; the second is the effect of an increased body mass acting on the bone tissue and requiring a stronger antigravitational thigh musculature which additionally stimulantes the development of the bone tissue.

The differences between individual groups in respect to the circumferences measured on the upper extremities result from specific training factors which affect in a selective manner the development of muscles on the upper extremities; body mass has no effect on the occurrence of differences between the circumferences of the upper extremities.

The largest diameters of bones and joints are found in alpine skiers; after them ski jumpers follow. Rowers and swimmers have even smaller bone diameters of the lower extremities than the reference group of sportsmen. It may be concluded that these differences are the result of two factors; the first one is the fact that in the age of adolescence (reference group) the development is focused primarily on the skeleton (large diameters of bones and joints) due to the influence of the general pattern of physical development (Singer 1976) and locomotor activity. According to the biological clock, the skeleton develops first, and only after that the muscle mass starts to increase since the muscular force of an individual must be coordinated with the structure and mass of bones, tendons, joints, connective tissue and muscles themselves so that optimum safety in statical and dynamic functioning of the locomotor system is guaranted. The second important factor affecting the development of the skeleton is body mass since in increased body mass even the maintenance of an erect standing posture represents already a sufficiently large stimulus for the development of stronger antigravitational femur musculature and bones. As all sportsmen covered by the research have a larger body mass than the reference group, larger diameters of bones and joints of the lower extremities were to be expected if the training required to overcome own body mass. However, in rowers and swimmers this stimulation effect of the body mass does not occur: rowers sit and swimmers glide through water.

Since morphofunctional indicators lag in development behind the skeleton ones (Bulgakova 1988), it is understandable that all groups of sportsmen have larger circumferences both on the upper as well as on the lower extremities than the reference group. From all groups, alpine skiers have, the largest circumferences which applies also to the upper extremities. This indicates that the properties of their muscles are different: they must be strong and explosive in contrast with those of rowers and swimmers whose training is aimed at developing strong and endurable muscles which are smaller in cross-section in comparison to that of alpine skiers. The smallest circumferences of the upper extremities have, as expected, ski jumpers.

The largest circumferences of the lower extremities can be found in alpine skiers, then follow swimmers (on account of larger skinfolds) and ski jumpers; the smallest circumferences can be established in rowers.

All groups of sportsmen have larger body masses than the reference group, while all skinfolds (abdominal, on the thigh and triceps) are smaller than the mean of the reference group.

The body dimensions of the best rowers (R.K. and M.S.) is in accord with the body dimensions of the group (Figure 1 and 2). The form of the curve of the best swimmer B.P. (Figure 1) is similar, only that all values of the circumferences, body mass and skinfolds are larger by 1 to 2 Z-values.

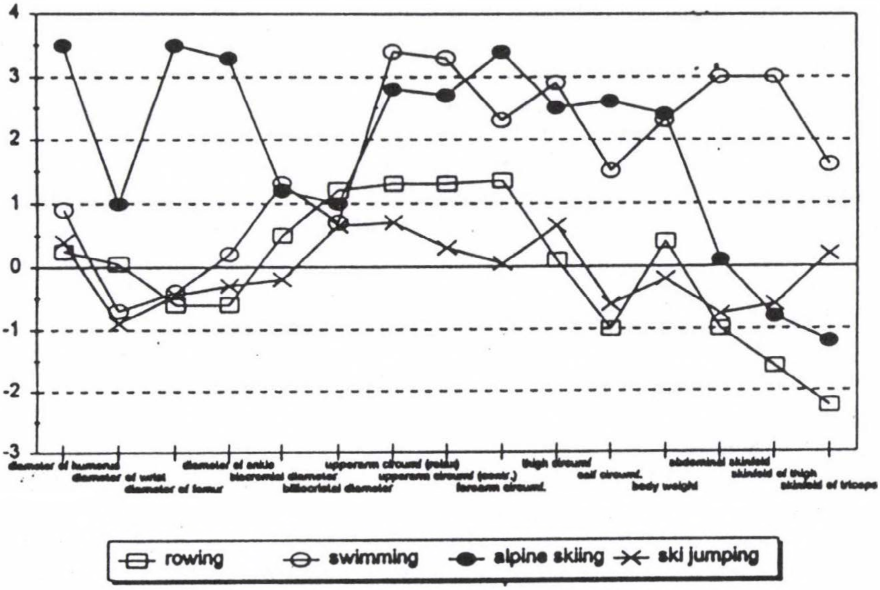

Fig. 1: Body profiles: the best representatives of the selected sports disciplines

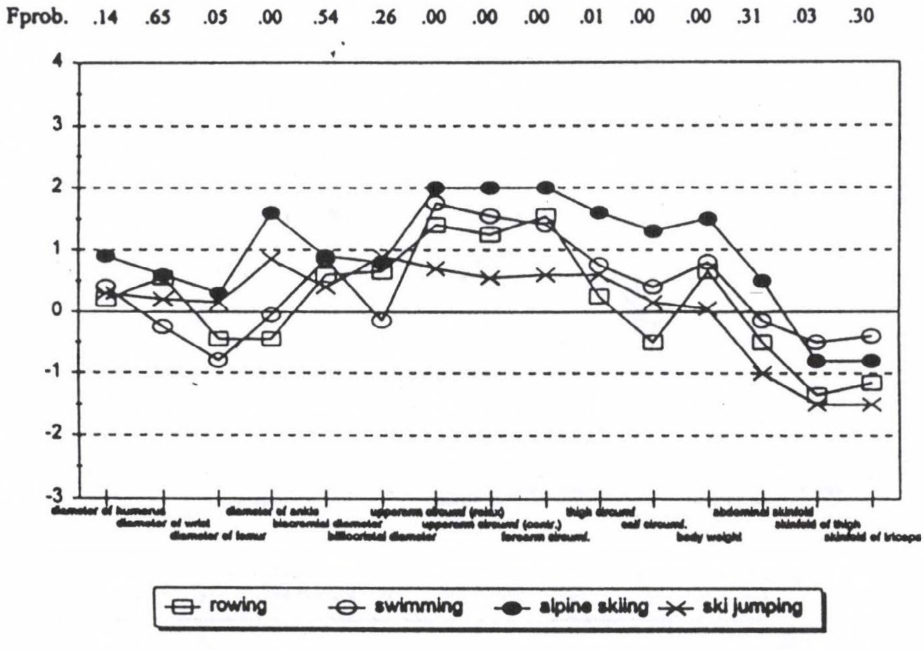

Fig. 2: Body profiles of the selected sports and results (F test) of oneway ANOVA

The best alpine skier B.K. (Figure 1) differs from the average of the group in extremely large diameters of the upper arm, femur and ankle joint (deviating by 1 to 2 Z-values in the positive direction) and a large circumference of the forearm and calf, which indicates that the robustness of the skeleton-muscular system is primarily genetically determined. The best ski jumper P.U. has smaller diameters of the wrist and ankle and the circumferences of the forearm and calves which points to genetically conditioned normosthenia or even asthenia. Hrisanof (1987) states that among young ski jumpers, more explosive power and better technical skill are typical of those ski jumpers whose constitutional type is asthenic or normasthenic in contrast with those who are hypersthenic.

Resently, phantom values of anthropometric variables are more and more often used as reference values in the representation of the body proportions. These values are equal for male and female population, and enable to establishthe differences between the sexes, as well as to observe the laws of biological development (Figure 3).

Body composition, body surface area and muscular-bone indices. The largest diameters of bones and joints and also the largest lean circumferences in alpine skiers (Table 4) are the result of the training process which in interaction with body mass develops strong explosive musculature which requires a firm, massive skeleton able to resist active forces exerted by muscles. The best alpine skier B.K. is a typical case of all the aforementioned morphologic characteristics; however, between him and other subjects there exists an essential difference: among all measured alpine skiers B.K. has the smallest surface area of the body (Figures 4 and 5).

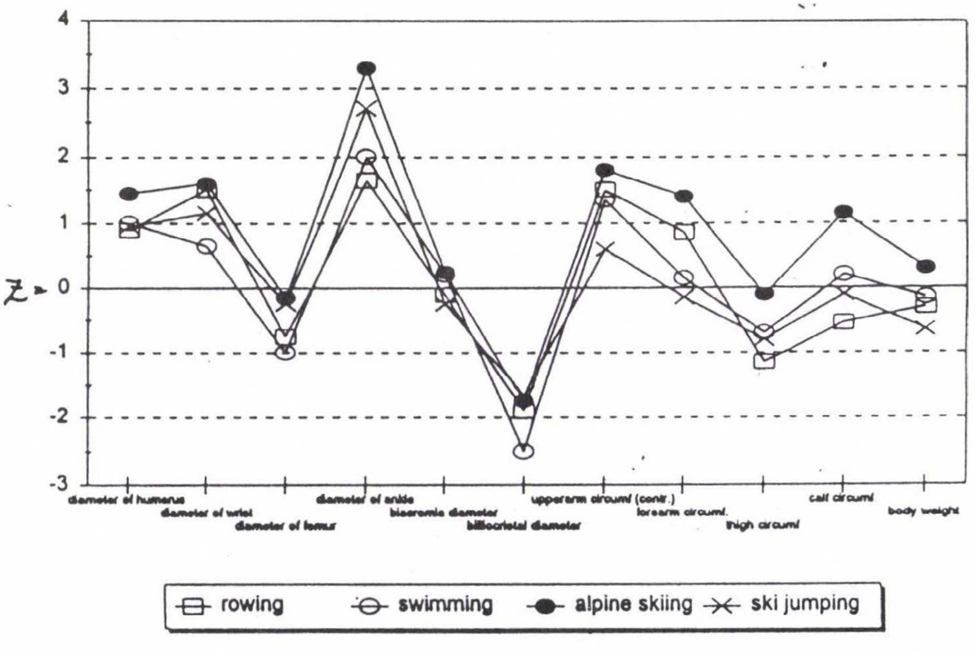

Fig. 3: Body profiles of the selected sports groups – fantom values

Table 4: Body area, body composition and muscular-bone indices of the selected sport groups (basic statistical parameters and variance analysis - F prob.)

	Rowers	Swimmers	Alpine skiers	Ski jumpers	F
Body area	2.095 ± .06	2.018 ± .14	1.982 ± .13	1.853 ± .09	.002
% of body fat	7.17 ± 1.9	8.04 ± 1.6	8.49 ± .15	6.40 ± 1.1	.201
% of bone mass	17.18 ± .95	16.49 ± .80	17.03 ± .95	18.81 ± .70	.000
% of muscular mass	50.49 ± 1.1	50.87 ± 1.5	53.65 ± 2.5	53.84 ± 2.5	.006
Muscul. bone ind. of upper extremities:					
MBI 1 – MKI 1	.42 ± .16	.40 ± .12	.46 ± .08	.57 ± .08	.393
MBI 2 – MKI 2	4.09 ± .25	4.17 ± .22	4.16 ± .19	3.87 ± .17	.051
MBI 3 – MKI 3	3.88 ± .22	3.70 ± .16	3.88 ± .08	3.64 ± .11	.021
Muscul. bone ind. of legs:					
MBI 4 – MKI 4	5.58 ± .12	5.68 ± .20	5.89 ± .28	5.59 ± .25	.034
MBI 5 – MKI 5	3.71 ± .15	3.97 ± .16	4.02 ± .23	3.76 ± .10	.001
Trunc index	1.49 ± .13	1.57 ± .07	1.49 ± .08	1.45 ± .08	.173
Lean upper arm circ. (AONČ)	29.1 ± 1.2	28.9 ± 1.1	29.1 ± 1.4	26.4 ± 1.4	.004
Lean thigh circ. (AOSČ)	54.1 ± 1.8	54.0 ± 3.0	56.0 ± 3.0	53.1 ± 2.5	.198
Lean calf circ. (AOMČ)	35.9 ± 2.1	36.8 ± 1.7	38.5 ± 2.7	35.9 ± 2.3	.050

MBI 1= (upper arm circ. contr. - upper arm circ. relax)/diameter of humerus
MBI 2 = upper arm circum./diameter of humerus
MBI 3 = forearm circum./diameter of humerus
MBI 4 = thigh circum./diameter of femur
MBI 5 = calf circum./diameter of femur
Trunk index (INTR) = biacromial diameter/biiliocristal diameter

Rowers have the largest surface area of the body (Table 4) and high muscular-bone indices for the upper extremities (MBI 3). These are the results of specific training factors which selectively direct the largest amount of energy into upper extremities. Maximally strong and endurable musculature develops that does not need particularly robust bones and joints in contrast with strong and explosive musculature in alpine skiers (Figure4). The curve of the best rowers R.K. and M.J. (Figure 5) is as to its form almost identical with the curve of the mean values of the groups.

Swimmers have, similarly as rowers, large body surface area and lean circumference of the upper arm. High values of muscular-bone indices (MBI 2, 4, 5) are mainly on account of thicker skinfolds on the extremities which condition larger circumferences. They also have a markedly larger width of shoulders relative to the width of the pelvis (trunc index - INTR) (Table 4 and Figure 4). The curve of the best swimmer (Figure 5) is to its form similar to the curve of the mean of the group. All values, except the lean calf circumference are higher by 1 - 2 Z-values. Extremely high value of the ratio between the thigh circumference and the femur circumference (MBI 4) is the result of a large circumference, which is to a large extent a consequence of a large skinfold on the thigh (20 mm).

Ski jumpers have the largest percentage of bone and muscle tissue, the smallest body surface area and a relatively wide pelvis relative to the shoulder width (INTR) (Table 4 and Figure 4). The best ski jumper P.U. (Figure 5) differs from the average most in respect of the body surface area, lean calf circumference and the ratio between the width of the shoulders and the pelvis (INTR) which are smaller.

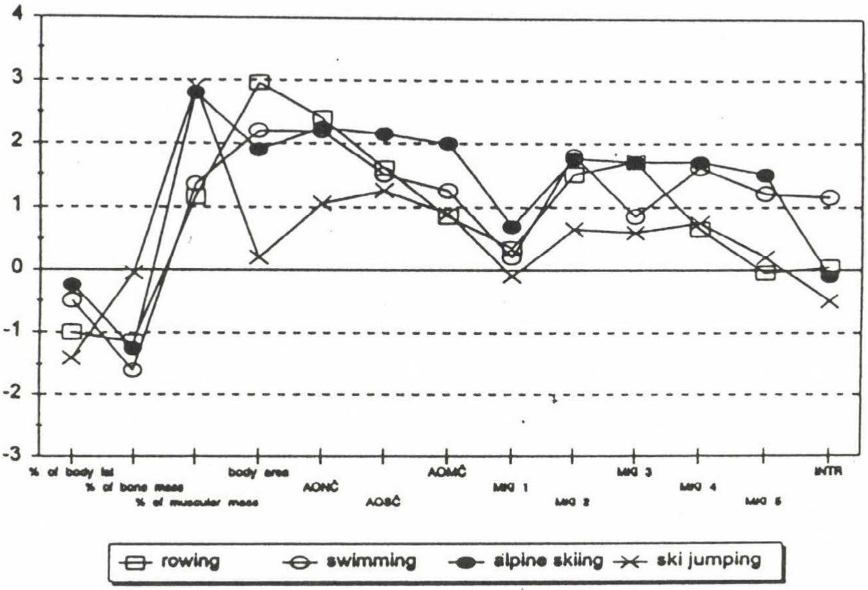

Fig. 4: Profiles of body composition, body area and muscular – bone indices of the selected sports groups

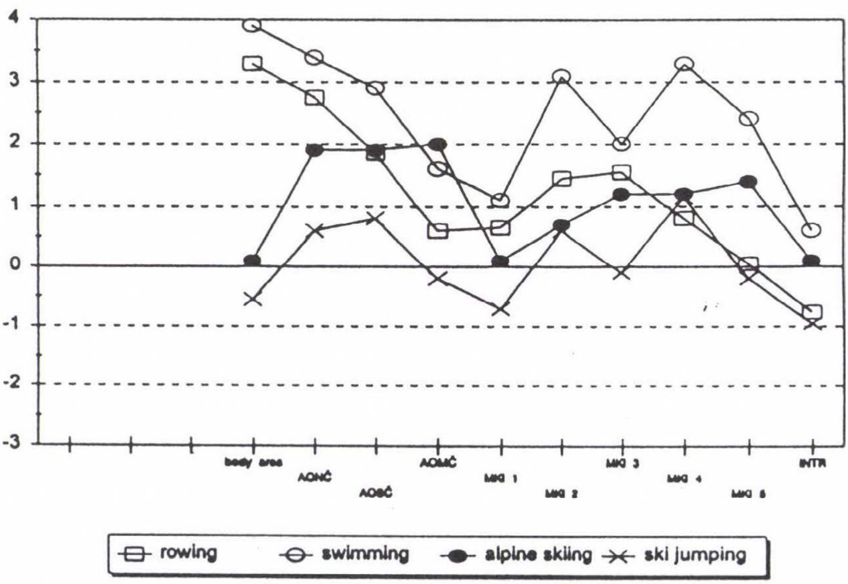

Fig. 5: Profiles of body area and muscular – bone indices of the best representatives of the selected sports disciplines

From the curves of body dimensions of the best representatives of the selected sports it may be concluded that the best representatives do not differ in the width of the pelvis (Figure 2), which is among all anthropometric variables selected (except the body height) to the largest extent heriditary. They are also similar as regards robustness of the bones and joints; the exception is the best alpine skier who deviates by 3 - 4 Z-values towards higher values. Best adaptation to the requirements of musculature and body mass shows the diameter of the femur, which fact is evident from Figure 4 (MBI 4). As to this index, all best sportsmen are equal; from this rule only the best swimmer deviates: his high index value is the consequence of a markedly thick layer of fat on the thigh (skinfold on the thigh is 20 mm).

Anthropometric somatotypes according to Heath-Carter. By somatotype, rowers are ectomorphic-mesomorphs, swimmers are balanced mesomorphs, alpine skiers are also balanced mesomorphs, and ski jumpers are mesomorph-ectomorphs (Table 5, Figure 6).

Table 5: Somatotype components
(basic statistical parameters and variance analysis - F prob.)

	Rowers	Swimmers	Alpine skiers	Ski jumpers	F
Endomorphy	1,49 ± .59	1,83 ± .40	1,98 ± .72	1,30 ± .37	.117
Mesomorphy	4,58 ± .61	4,96 ± .16	5,94 ± .55	4,69 ± .72	.002
Ectomorphy	2,92 ± .61	2,62 ± .25	2,05 ± .62	3,49 ± .55	.002

The best coxless pair rowers (R.K. and M.J.) are ectomorph-mesomorphs; the best Slovene alpine skier B.K. is on the border of a balanced mesomorph and endomorph-mesomorph; the best Slovene swimmer B.P. is an endomorph-mesomorph; and the best Slovene ski jumper (P.U.) is a mesomorph-ectomorph (Table 6 and Figure 6).

Table 6: Somatotype components of the best representatives in each sport

	Rowers (R.K.+M.J.)	Swimmer B.P.	Alpine skier B.K.	Ski jumper P.U.
Endomorphy	1.06	4.00	2.14	1.83
Mesomorphy	4.41	6.40	7.70	4.12
Ectomorphy	3.18	1.15	1.02	3.92

Conclusion

Body dimensions: The groups of sportsmen differ in ankle diameter, all circumferences of the extremities, body mass, diameter of femur and skinfold of the thigh.

Body composition, body surface area and muscle-bone indices: the groups differ in body surface area, percentage of muscle and bone matter, but not in percentage of fat. In the muscle and bone indices differences exist only in lean upper-arm circumference, and in the ratio between calf circumference and diameter of femur.

By somatotype, rowers are ectomorphic-mesomorph, swimmers and alpine skiers are balanced mesomorphs, and ski jumpers are of mesomorph-ectomorph type.

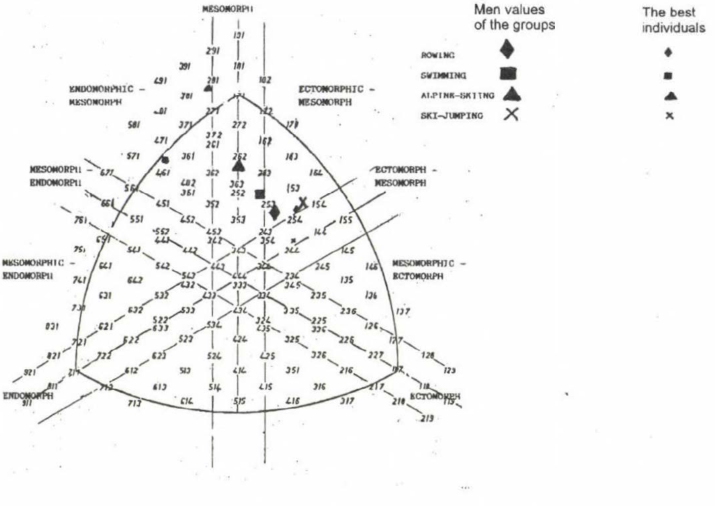

Fig. 6: Somatotypes: the best representatives of the selected sports disciplines and mean values of the groups

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