SOMATOTYPES IN SKIING

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ABSTRACT
Although the available studies on body types in ski sports are relatively sparse and rather old, there are clear indications that, especially in alpine skiing, top athletes have become stronger and heavier in the last three decades [43, 24]. According to Bahr and Tone [5] as well as Mildner et al. [19], the anthropometric profile and the somatotype, in particular the extent of muscular development in the lower extremities, are to be regarded as significant intrinsic risk factors for alpine skiing trauma [20]. Especially among men, the downhill racers tend to have a more pyknomorphic-hyperplastic constitution type or more mesomorph somatotype with longer trunk and shorter legs and higher BMI, while the slalom specialists tend to more leptomorphic values with longer legs and shorter trunk.

Keywords: sports anthropology; kinanthropometry; skiing; slalom; downhill racer; slalom somatotypes

HISTORICAL SPORTS ANTHROPOLOGICAL STUDIES ON SKIERS’ CONSTITUTION TYPES

For the first time, the body type of cross-country skiers was described by Kohlrausch in 1927 [16]; according to him, they share long legs with the other groups of runners in summer sports. Above all, he emphasizes the relative length of the thighs. Otherwise the cross-country skier would be closer to the decathlon than to the running disciplines in terms of mass, muscle development, chest circumference and width of the support belt with regard to the sport-specific requirement profile.
In contrast to the relatively tall and slim type of the cross-country skier, Kohlrausch [16] characterizes the ski jumper as smaller (body height 166 cm) with broad shoulders and hips, short legs and chunky physique, “in order to cope with the force of the impact”.

According to Janura et al. [15], a decisive factor for the increase in flight and jump distances was the reduction of the body mass index (BMI, see [21, 39]). Müller et al. [22] describe a decrease in BMI since 1970.

On the basis of a comprehensive study of 285 top athletes from different sports in the Netherlands, Maas [18] elaborated vividly descriptive, male sports types between 1965 and 1970. The cross-country skier (see Figure 1) is described as small and muscular with relatively broad shoulders and hips, large hands and long legs.

The special body features of the alpine skier were first described by Arnold [3, 4]. An extensive anthropometric investigation at Olympic Games, however, was first performed by Saller [30] on the occasion of the Games in Innsbruck in 1964.

**SKIERS’ BODY TYPES (SOMATOTYPES) IN THE SOMATOCHART**

In addition to pure body composition, the body types (constitution types) often also play a relevant role for potential competition success in winter sports. The importance of these constitutional prerequisites for performance applies in some sports in childhood and adolescence already.
Most kinanthropometric average values for the ski-jumpers’ somatotypes are found in the ectomesomeric region (with relatively high mesomorphy ratings), with several athlete collectives arranging along the balanced-mesomorphic boundary and the Nordic combiners orienting themselves further into the centre of the ecto-mesomorphic area.
The somatotype mean scores of the male cross-country skiers are all ectomesomorphic along the balanced-mesomorphic line, whereas the cross-country skiers are endomesomorphically located near the mesomorph-endomorphic boundary.

For alpine skiers, a wide spread of somatotypes throughout the mesomorphic-somatochart-third manifests. One recognizes a more tendentious placement of the male top athletes along the balanced mesomorphic line, the up-and-coming athletes above the mesomorphic-ectomorphic axis above the ectomorphic third, and the female elite athletes above the mesomorphic-endomorphic line above the endomorphic third. For many alpine skier groups, the endomorphism rating thus appears slightly higher than for cross-country skiers and ski jumpers.

A recent study by Aerenhouts et al. [1] compares the somatotypes of international top skiers from different countries with different downhill disciplines:
Table 1. Comparison of internationally successful alpine skiers of different nations (n = 25 women, n = 58 men), modified according to Aerenhouts et al. [1]

| Alpine Skiing | Women | | Men | | |
|---------------|-------|-------|------|------|
| Discipline    | Slalom| Downhill| Slalom| Downhill |
| Number (n)    | 11    | 9      | 17   | 26    |
| Ages (years)  | 21.3±2.8***| 25.6±2.5***| 22.5±3.2*| 25.8±4.2* |
| Height (cm)   | 167.7±5.2| 168.8±5.2| 178.8±5.1| 181.0±4.8 |
| Weight (kg)   | 65.8±3.9| 69.2±5.6| 80.8±7.2*| 87.0±5.5* |
| % body fat    | 24.4±3.0| 26.7±2.8| 12.9±3.1| 14.5±2.7 |
| BMI (kg/m²)   | 23.4±1.6| 24.3±1.1| 25.3±1.6*| 26.6±1.6* |
| Endomorphy    | 3.8±0.8| 4.4±0.7| 2.7±0.9| 3.0±0.6 |
| Mesomorphy    | 4.7±1.2| 4.5±0.5| 5.8±0.9*| 6.3±0.8* |
| Ekтомorphy    | 1.9±0.8| 1.6±0.4| 1.8±0.6| 1.4±0.6 |

Figure 5. Mean values of the somatotypes of international top alpine skiers, outlined by Aerenhouts et al. [1], D = downhill S = slalom, C = combination, women (pink, circles), men (blue, squares)
SKIERS’ BODY TYPES IN CONRAD’S CHECKERBOARD PATTERN GRAPHIC

The most extensive survey with this type system of alpine ski racers was carried out in the winter of 1974/1975 by Amman [2], who subjected the entire world elite to an anthropological investigation. A total of 87 World Cup riders from 14 countries were examined, among them the Swede Ingemar Stenmark as well as the Austrian Franz Klammer and Anton Steiner, the Swiss Bernhard Russi and Roland Collombin as well as the Germans Sepp Ferstl and Michael Veith.

Figure 6. Position of the total collective (black numerals) of alpine ski racers (n = 87) compared to ultra-long-distance runners (red numerals) in the checkerboard pattern graphic after Conrad [12]

As can be seen from the checkerboard graphic, most skiers focus in the lower right, pyknomorph-hyperplastic quadrant. If one adds the skiers from the adjacent, metroplastic and metromorphic fields, which delimit the lower, right square, then 76 of the 87 alpine ski racers have a constitutional type characterized by strong muscle development and relatively large body mass.

They differ significantly from the physique of the hypoplastic-leptomorphic ultra-long-distance runners, which appear mainly in the upper left area.

Unlike the downhill racers, the slalom specialists are slimmer, more delicate, and graceful, i.e. more hypoplastic and more leptomorph. According to Amman [2], the giant slalom riders are very similar to the slalom riders in many physical traits. The greater body height of the downhill specialists is mainly due to the greater length of the trunk and not to lengthening of the legs.
This results in the picture of the somewhat more leptomorph, long-legged and slender slalom and giant slalom rider compared to the rather pyknic and more massive downhill specialist.

The body type differences are very vividly exemplified by the long-time dominance of the slalom / giant slalom racer and a successful downhill rider, a World Cup winner in downhill skiing, in the checkerboard pattern graphic after Conrad.

While the slalom driver (Sl) is in the mesomorphic range, i.e. in the centre of the coordinate system, one can see the downhill specialist (Do) in the lower right corner of the pyknomorph-hyperplastic quadrant (Fig. 7).

The proportions of both athletes are again determined by means of proportion figures (Fig. 8). Clearly recognizable are the larger, relative leg length but shorter trunk length of the slalom rider (Fig. 10) as well as the large trunk length but relatively shorter legs of the downhill racer (Fig. 9).
Even if the listed constitutional biological surveys are already somewhat old, one recognizes the two basic constitutional types also in the comparison of the German male and female champions of the last decade, if one analyses only weight, body height and BMI.
Table 2. Overview of the German champions of the last decade in alpine skiing, differentiated according to the disciplines pairing slalom / giant slalom and downhill / super G with weight and height, as available on Wikipedia (accessed on 24.9.2017), with calculated BMI values

| German Champions     | Discipline       | Weight (kg) | Height (cm) | BMI (kg/m²) |
|----------------------|------------------|-------------|-------------|-------------|
| Felix Neureuther     | (Giant)Slalom    | 87          | 184         | 25.7        |
| Dominik Stehle       | (Giant)Slalom    | 83          | 176         | 26.8        |
| Fritz Dopfer         | (Giant)Slalom    | 85          | 188         | 24.0        |
| Stefan Kogler        | (Giant)Slalom    | 96          | 193         | 25.8        |
| Dominik Schwaiger    | (Giant)Slalom    | 82          | 180         | 25.3        |
| Linus Straßer        | (Giant)Slalom    | 75          | 183         | 22.4        |
| Alexander Schmid     | (Giant)Slalom    | 70          | 178         | 22.1        |
| Stephan Keppler      | Downhill/Super G | 93          | 183         | 27.8        |
| Hannes Wagner        | Downhill/Super G | 97          | 190         | 26.9        |
| Felix Neureuther     | Downhill/Super G | 87          | 184         | 25.7        |
| Philipp Zepnik       | Downhill/Super G | 92          | 185         | 26.9        |
| Andreas Sander       | Downhill/Super G | 91          | 178         | 28.7        |
| Klaus Brandner       | Downhill/Super G | 85          | 177         | 27.1        |
| Thomas Dreßen        | Downhill/Super G | 97          | 188         | 27.4        |
| Josef Ferstl         | Downhill/Super G | 85          | 179         | 26.5        |

The average weight of the German downhill / super G group with 90.9 ± 4.9 kg is significantly higher than that of the (giant) slalom racers with 82.6 ± 8.4 kg (p< 0.05). The BMI differences are even very significant (27.1 ± 0.9 kg/m² vs. 24.6 ± 1.8 kg/m²). However, the average body height does not differ (each 183 cm).

By contrast, the results on the ladies are less obvious.
Table 3. Overview of the German female champions of the last decade in alpine skiing, differentiated according to the disciplines pairing slalom / giant slalom and downhill / super G with weight and height, as available on Wikipedia (accessed on 24.9.2017), with calculated BMI values

| German Champions          | Discipline       | Weight (kg) | Height(cm) | BMI (kg/m²) |
|---------------------------|------------------|-------------|------------|-------------|
| Monika Bergmann           | (Giant)Slalom    | 74          | 176        | 23.9        |
| Veronika Staber           | (Giant)Slalom    | 64          | 167        | 22.9        |
| Viktoria Rebensburg       | (Giant)Slalom    | 67          | 170        | 23.2        |
| Kathrin Hölzl             | (Giant)Slalom    | 59          | 163        | 22.2        |
| Fanny Chmelar             | (Giant)Slalom    | 83          | 187        | 23.7        |
| Susanne Riesch            | (Giant)Slalom    | 79          | 181        | 24.1        |
| Nina Perner               | (Giant)Slalom    | 60          | 164        | 22.3        |
| Veronika Staber           | (Giant)Slalom    | 64          | 167        | 22.9        |
| Christina Geiger          | (Giant)Slalom    | 67          | 170        | 23.2        |
| Simona Hösl              | (Giant)Slalom    | 56          | 165        | 20.6        |
| Veronique Hronek          | (Giant)Slalom    | 62          | 157        | 25.2        |
| Barbara Wirth             | (Giant)Slalom    | 67          | 170        | 23.2        |
| Marlene Schmotz           | (Giant)Slalom    | 62          | 163        | 23.3        |
| Lena Dürr                 | (Giant)Slalom    | 64          | 173        | 21.4        |
| Susanne Weinbuchner       | (Giant)Slalom    | 64          | 167        | 22.9        |
| Maria Höfl-Riesch         | Downhill/Super G | 78          | 182        | 23.5        |
| Hilde Gerg                | Downhill/Super G | 70          | 171        | 23.9        |
| Gina Stechert             | Downhill/Super G | 75          | 172        | 25.4        |
| Viktoria Rebensburg       | Downhill/Super G | 67          | 170        | 23.2        |
| Lena Dürr                 | Downhill/Super G | 64          | 173        | 21.4        |
| Fanny Chmelar             | Downhill/Super G | 83          | 187        | 23.7        |
| Isabelle Stiepel          | Downhill/Super G | 71          | 178        | 22.4        |
| Veronique Hronek          | Downhill/Super G | 62          | 157        | 25.2        |
| Michaela Wenig            | Downhill/Super G | 77          | 176        | 24.9        |
| Marina Wallner            | Downhill/Super G | 75          | 170        | 26.0        |
| Kira Weidle               | Downhill/Super G | 68          | 172        | 23.0        |
| Susanne Weinbuchner       | Downhill/Super G | 64          | 167        | 22.9        |
For women, however, there are no significant differences between downhill / super G and (giant) slalom groups in terms of weight, body height and BMI of the German champions ($71.2 \pm 6.5 \text{ vs. } 66.1 \pm 7.4 \text{ kg, } 172 \pm 7.5 \text{ vs. } 169.3 \pm 7.6 \text{ cm, } 23.8 \pm 1.4 \text{ vs. } 23.0 \pm 1.1 \text{ kg} / \text{ m}^2$).

REFERENCES

1. Aerenhouts D., Clijsen R., Fässler R., Clarys P., Taeymans, J. (2012). Event-specific somatotype and physical characteristics of male and female elite alpine skiers. In: Müller E., Lindinger St., Stöggl Th. (Eds.), Science and Skiing. Maidenhead: Meyer & Meyer Sport Ltd., pp. 51–58.
2. Ammann E. (1998). Körperbau und sportliche Leistung im alpinen Skirennenport. In: Bernhard W., Jung K. (Hrsg.), unter Mitarbeit von Amman A., Raschka C. et al., Sportanthropologie. Fragestellungen, Methoden und Ergebnisse am Beispiel der Laufdisziplinen und des alpinen Skirennports. Stuttgart, Jena, Lübeck, Ulm: Gustav Fischer-Verlag, S. 292–350.
3. Arnold A. (1933). Konstitution und ihr Einfluss auf die Leistung. In: Knoll W., Arnold A. (Hrsg.), Handbuch der normalen und pathologischen Physiologie der Leibesübungen. Leipzig: Johann Ambrosius Barth-Verlag.
4. Arnold A. (1956). Einfluss der Leibesübungen auf Körper und Konstitution. In: Arnold A. (Hrsg.), Lehrbuch der Sportmedizin. Leipzig: Johann Ambrosius Barth-Verlag.
5. Bahr R., Tone B. (2010). A scientific approach to injury prevention in world cup alpine skiing. Keynote Lecture at the Opening Ceremony of the 5th International Congress on Science and Skiing. St. Christopher am Arlberg, Österreich.
6. Chogovadze A., Izrael Z. (1968). O somatometriceskoj I somatotipologiceskoj characteristikach begunov, chodokov i lyznikov. Voprosy antropologii, 29, 90–104.
7. Chovanová E. (1976). Somatotypes of top-class skiers (jumpers, cross-country runners, combined events competitors and downhill runners). Acta Facultatis Rerum Naturalium Universitatis Comenianae – Anthropologia, 24, 63–77.
8. Chovanová E. (1976). Body structure of elite ice hockey players and skiers. Doctoral Dissertation. Bratislava, Czechoslovakia: Comenius University.
9. Chovanová E. (1979). Physique de top ice-hockey players and skiers and its relation to their specialization. Collegium Antropologicum, 3, 189–193.
10. Chovanová E. (1981). Problematika výberu talentovaných lyžiarov-zjazdárov zo somatického hładiska. Teorie a Praxe telesné Výchovy, 29, 212–218.
11. Conrad K. (1941). Der Konstitutionstypus als genetisches Problem. Berlin: Springer-Verlag.
12. Conrad K. (1963). Der Konstitutionstypus. Berlin, Göttingen, Heidelberg: Springer-Verlag.
13. Gualdi-Russo E., Graziani I. (1993). Anthropometric somatotype of Italian sport participants. The Journal of Sports Medicine and Physical Fitness, 33 (3), 282–291.
14. Heath B.H., Carter J.E.L. (1967). A modified somatotype method. Am J Physic Anthropol, 27, 57–74. https://doi.org/10.1002/ajpa.1330270108
15. Janura M., Cabell L., Elfmark M., Vaverka F. (2010). Kinematic characteristics of the ski jump inrun: a 10-year longitudinal study. J of Applied Biomechanics, 2, 196–204. https://doi.org/10.1123/jab.26.2.196
16. Kohlrausch W. (1927). Sporttypen. In: Rautmann H. (Hrsg.), Arzt und Skilauf. Jena: Gustav Fischer-Verlag, S. 110–147.
17. Kretschmer E. (1921). Körperbau und Charakter. Berlin: Springer-Verlag.
18. Maas G.D. (1974). The physique of athletes. An anthropometric study of 285 top sportsmen from 14 sports in a total of 774 athletes. Leiden: Leiden University Press.
19. Mildner E., Barth M., Ehn G., Kriebernegg R., Staudacher A., Raschner C. (2012). Relationship between physical fitness, ski technique and racing results of young alpine ski racers. In: Müller, E., Lindinger St., Stöggl Th. (Eds.), Science and Skiing V. Maidenhead: Meyer & Meyer Sport Ltd., pp. 282–290.
20. Minetti A.E., Susta D. (2012). The maximum negative power and force modulation during hard and soft landing in alpine skiers. In: Müller E., Lindinger St., Stöggl Th. (Eds.), Science and Skiing V. Maidenhead: Meyer & Meyer Sport Ltd., pp. 291–297.
21. Müller W., DeVane Y T. (1996). The influence of body weight on the ski jumping performance. In: Haake S. (Ed.), The Engineering of Sport. Rotterdam: A.A.Balkema Verlag, pp. 63–69.
22. Müller W., Gröschl W., Müller R., Sudi K. (2006). Underweight in ski jumping. The solution of the problem. Int J Sports Med, 27, 926–934. https://doi.org/10.1055/s-2006-923844
23. Orvanová F. (1987). Physical structure of winter sports athletes. Journal of Sports Sciences, 5, 197–248. https://doi.org/10.1080/02640418708729779
24. Osognach C., Colombo M., Bosio A., Freschi M., Buselli P., Roi G.S. (2006). Physical profile of top level alpine skiers: anthropometrical differences between Italian National Teams competing in 1982, 1999 and 2005 World Cup. Proceedings in the XV International Congress on Sports Rehabilitation and Traumatology, Turin, Italy.
25. Raschka C. (2006). Sportanthropologie. Leitfaden der modernen, vergleichenden Sportanthropologie, Sportanthropometrie und trainingsrelevanten Konstitutionsbiologie. 1. Auflage. Köln: Sportverlag Strauß, 342 S.
26. Raschka C. (2016). Körperbau und Körperzusammensetzung (Sportanthropologie). In: Raschka C., Nitsche L. (Eds.), Praktische Sportmedizin. Stuttgart, New York: Thieme Verlag, S. 45–64.
27. Raschka C. Nitsche L. (Eds.). (2016). Praktische Sportmedizin. Stuttgart: Georg Thieme Verlag.
28. Ross W.D., Day J.A.P. (1972). Physique and performance of young skiers. Journal of Sports Medicine, 12, 30–37.
29. Ross W.D., Brown S.R., Faulkner R.A., Savage, M.V. (1976). Age of menarche of elite Canadian skaters and skiers. Canadian Journal of Applied Sport Sciences, 1, 191–193.
30. Saller K. (1966). Wintersporttypen. Untersuchungen bei der Winterolympiade 1964 in Innsbruck. Anthropologie, 4, 33–39.
31. Schuelke M., Wagner K.R., Stolz L.E., Hübner C., Riebel T., Kömen W., Braun T., Tobin J.F., Lee S.-J. (2004). Myostatin mutation associated with gross muscle hypertrophy in a child. N Engl J Med, 350, 2682–2688. https://doi.org/10.1056/NEJMoa040933
32. Sheldon W.H. (1940). The varieties of human physique. New York, London: Harper.
33. Sinning W.E., Cunningham L.N., Racaniello A.P., Sholes J.L. (1977). Body composition and somatotype of male and female Nordic skiers. Research Quarterly, 48, 741–749. https://doi.org/10.1080/10671315.1977.10615488
34. Song T.M.K. (1982). Relationship of physiological characteristics to skiing performance. The Physician and Sports Medicine, 10, 97–102. https://doi.org/10.1080/00913847.1982.11947396
35. Štěpnička J. (1974). Typologie sportovců. Acta Universitatis Carolinae Gymnica, 1, 67–90.
36. Štěpnička J. (1977). Somatotypes of Czechoslovak athletes. In: Eiben O.G. (Hrsg.), Growth and Development. Physique. Budapest: Akadémiai Kiadó, S. 357–364.
37. Štěpnička J. (1977). Motorické testy a somatotype jako kritérium talent pro sport. Teorie a Praxe telesné Výchovy, 25, 647–672.
38. Štěpnička J., Broda T. (1977). Somatotypy mladých sjezdařů. Teorie a Praxe telesné Výchovy, 25, 166–169.
39. Sudi K., Öttl K., Payerl D., Baumgartl P., Tauschmann K., Müller W. (2004). Anorexia athletica. Nutrition (Burbank, Los Angeles County, California), 20, 657–661. https://doi.org/10.1016/j.nut.2004.04.019
40. Taeymans J., Aerenhouts D., Clijsen R., Fässler R., Clark P., Baeyens P.-P. (2012). Somatotype and kinanthropometric characteristics of male and female junior and elite senior alpine skiers. In: Müller E., Lindinger St., Stöggl Th. (Eds.), Science and Skiing V. Maidenhead: Meyer & Meyer Sport Ltd., S. 452–460.
41. Tittel K., Wutscherk H. (1972). Sportanthropometrie. Leipzig: Barth.
42. Toteva M., Sumanov B. (1984). Sravnitelna somatotipna charakteristika na sstezateli ot razlicnite ski-disciplini. Naucni trudove 25, Sofia: ECIPKFKS – VIF ‘Georgi Dimitrov’.
43. White A.T., Johnson S.C. (1993). Physiological aspects and injury in elite Alpine skiers. Sports Med, 15 (3), 170–178.
https://doi.org/10.2165/00007256-199315030-00003
44. Znášik A. (1979). Sledovanie motorických schopností a somatotypov lyžiarov – zjazdárov a žiakov ZDŠ v Bratislave. M.A. Thesis, Bratislava: Faculty of PE, Comenius University.

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