Correlations Between High Level Sport-Climbing and the Development of Adolescents

Isabelle Schöffl
Klinikum Bamberg

Volker Schöffl
Friedrich-Alexander-University

J. Dötsch
University of Cologne

H.G. Dörr and J. Jüngert
Friedrich-Alexander-University

Over the last years concerns have been raised about the health effects particular on young climbers due to the observation of short stature with low body weight and body fat in sports climbers. The aim of this study was to investigate anthropometric and hormonal data for climbers of the German Junior national team. 16 climbers were compared with 14—age matched nonclimbers with respect to several anthropometric variables, leptin level, and climbing characteristics. Height, weight and body mass index (BMI) standard deviation scores (SDS) for boys were not significantly different from the controls, whereas girls had significantly lower SDS-values for weight and BMI. In comparison with the control group boys and girls had a lower skinfold thickness. The leptin values were lower than the calculated leptin levels but only reached significance for the girls. The young athletes of the GJNT were neither of short stature nor thin when compared with a physically active control group. The low body fat in boys and girls was within expected limits. The lower leptin levels might be attributed to a decrease in total body fat.

Sport climbing has become more and more popular over the last 30 years both as a recreational physical activity, but especially as a competitive sport. The increasing number of indoor facilities, widespread popularity of this sport, and the
development of local, national, and international competitions have led to the study of the physical characteristics that may be associated with high level performance. Several studies found elite adult competitive climbers to be short in stature with low body mass and very low fat percentages (3,17,22,23,25). Although relatively high hand grip strength/body mass ratios have been reported in high level climbers (7,25), the absolute handgrip strengths are moderate (25), suggesting that the high strength/mass ratios are due to the effect of low body mass.

The association of high-level climbing performance with small stature and low body fat percentage along with the possibility of improving strength/mass ratio through body mass reduction, has raised concern about the potential health effects on climbers (24). Sports climbing shares the trend of achieving extremely low body weight with other sports in which physical performance is determined not only by the motor abilities of the athletes but also to a large extent by a low body weight, i.e., ski jumping, road cycling, woman’s acrobatic gymnastics, rhythmic gymnastics, and long-distance running (19). The concept of the reduction in body mass and/or the loss in body fat mass based on performance and not on appearance or excessive concern about body shape has lead to the introduction of the Anorexia athletica. Although Anorexia athletica resembles Anorexia nervosa with the high levels of exercise and the disordered eating habits it is not classified as a clinical eating disorder but as abnormal eating behavior (20). To reduce percentage of body fat, elite athletes often have diets too low in energy and nutrients. This in turn leads to deficits in micronutrients (19). Other effects of Anorexia athletica are endocrine abnormalities (4) such as delayed onset of puberty, menarche, menstrual irregularities and decreased bone formation (also recognized as the Female Athlete Triad (2,10)), but also to a loss of hormones related to fat mass, e.g., leptin, a hormone produced by the fat cells, which regulates appetite and energy expenditure (12,26). Leptin and ghrelin are two hormones that have been recognized to have a major influence on energy balance. Leptin is a mediator of long-term regulation of energy balance, suppressing food intake and thereby inducing weight loss. Ghrelin, secreted by the stomach, on the other hand is a fast-acting hormone, seemingly playing a role in meal initiation. Both originate in the periphery and signal through different pathways to the brain, particularly to the hypothalamus. In the hypothalamus, activation of the leptin or ghrelin receptor initiates different signaling cascades leading to changes in food intake. Furthermore, regulation of the effects of ghrelin on hypothalamic neurones (ghrelin blocks leptin’s action through the activation of the hypothalamic NPY/Y1 receptor pathway) has been suggested to be one of the important mechanisms by which leptin may control food intake and body weight (11).

Although there is only anecdotal data on eating disorders and unrealistic weight reduction practices in climbers, Austria has introduced a minimum BMI that has to be met by the climbers to participate in competitions (16). Whether the selected levels of limitation are justifiable or reasonable for climbers is difficult to judge, as there are few published anthropometrical data about competitive sport climbers. Because the energy and nutritional inadequacies combined with the use of purging methods can be found in young athletes, and restrictive eating behavior may become the norm at a young age, special attention needs to be paid to adolescents. The aim of this study was to evaluate anthropometry, developmental and hormonal data for high-level climbers of the German Junior National Team and to compare these data with an age matched group of physically active youth not performing at a high level.
Methods

16 adolescents of the German Junior National Team (GJNT) were studied, 9 boys with an average chronological age (CA) of 16.8 ± 2.3 (SD) years and 7 girls with an average CA of 17.2 ± 2.8 years. As a control group we recruited 14 nonclimbing adolescents, 8 boys with a mean CA of 15.9 ± 1.8 years and 6 girls with a CA of 16.3 ± 2.5 years. The control group consisted of active adolescents who did sports on a regular but noncompetitive basis. The study was approved by an ethics committee, and subjects as well as their parents provided assent and written permission, respectively. A questionnaire was employed to investigate the eating habits (fat reduced, normal), pubertal development (time of menarche, pubarche) and menstrual cycle. In another questionnaire the climbers were asked about their training habits (number of training session per week, hours spent per training, type of training) and climbing difficulties (in UIAA—scale: Union Internationale des Associations d’Alpinisme / International Mountaineering and Climbing Federation).

The body composition was measured using Bioelectrical impedance analysis (BodyComp V7.0, MEDI CAL HealthCare, Karlsruhe, Germany) for extracellular mass, body cell mass, fat free mass, fat mass, extracellular water, weight and other parameters.

Furthermore we measured body height and skinfold thickness using a caliper (ccu-Measure, LLC, Greenwood Village, Co, Usa) at the scapula. Body height, weight and BMI was then transferred in SDS (standard deviation score) values using the LMS method (The distribution of a measurement as it changes according to age is shown by the Reference centile curves. The changing distribution of three curves representing the median (M), coefficient of variation (S) and skewness (L) which is expressed as a Box-Cox power are summarized by the LMS method) proposed by Cole and Green (5). We calculated the ape index of each individual by dividing the length of each climber by the length of his arm span. A ratio of more than one signifies that the arm span is higher than the body height and leads to a so called positive ape index.

Furthermore, we corrected height SDS (H-SDS) of each member of the GJNT with target height SDS (TH-SDS) of the parents (mean of the parents height plus 6.5 cm for boys and minus 6.5 cm for girls) by the following formula: corrected H-SDS = H-SDS minus TH-SDS. This correction for height is important as sport climbers are described to be of smaller height (13,24) and the question arises whether this is a consequence of dietary restrictions or of their anthropometric background.

Serum-Leptin level was measured by an in-house Radio–Immuno-Assay (RIA; 15) in the venous blood, serum-grehlin by a Radio-immuno-assay (RIA, R 90, Medignost, Reutlingen-Germany). With regard to pubertal stage, all participants were mature determined by clinical examination using the Tanner stages (21).

Statistical analysis was performed using Microsoft Excel 2000 for data collection and SPSS 14.0 (SPSS Inc., Chicago, IL). All measured values are reported as means and standard deviations. The Kologomorov-Smirnov test was used to check for normal distribution. Homogeneity of variance was investigated using Levine’s F-test. For normally distributed variables differences within and between groups were assessed with paired and unpaired t tests, otherwise the Wilcoxon or the Whitney-Mann-U tests were used. All tests were 2-tailed, a 5% probability level was considered significant (*). Pearson or Spearmen correlation coefficients were used to investigate univariate correlation between independent variables and
Results

There was no difference between the GJNT and their respective control groups regarding eating habits or pubertal development. The mean CA of the GJNT and their respective control groups was not significantly different. The boys of the GJNT climbed significantly better (mean = 9.7 ± 0.45 in UIAA) than the girls (mean = 8.83 ± 0.50). Table 1 and 2 present means (SD) and minimum-maximum ranges for parameters concerned with the climbing specialties of the girls and boys of the GJNT respectively. Although the girls trained more often over the week the boys spent more hours in training. The years of climbing were comparable. The arm span of the girls was not significantly different from their height, however the boys had a significantly higher arm span/height ratio, leading to a positive so-called ape index of 1.03. However the ape index showed no correlation with climbing ability in any of the tested groups (boys of the GJNT, girls of the GJNT, both genders taken together).

SDS values of the girls and the boys of the GJNT are shown in Figure 1. The boys were not significantly different with regard to height, weight or BMI from the standard population. The girls had significantly lower weight and BMI SDS values.

The differences between the means of the GJNT and their respective control groups are shown in Table 3 for the girls and Table 4 for the boys (p < .05 is considered significant). Although the girls were shorter, lighter and had a lower BMI than their control group, only the weight proved to be significant. The leptin values were not significantly different. The boys were also shorter, lighter, had a lower BMI and lower leptin values than their control group, but none of the differences reached significance. The serum-levels of ghrelin did not reach significant differences between the GJNT and their respective control groups. With respect to skinfold thickness the

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Mean (sd)</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Climbing grade (UIAA)</td>
<td>8.8 (0.50)</td>
<td>8</td>
<td>9.3</td>
</tr>
<tr>
<td>Years of climbing (y)</td>
<td>6.9 (2.0)</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>Training sessions per week</td>
<td>5.4 (4.3)</td>
<td>3</td>
<td>15</td>
</tr>
<tr>
<td>Training hours</td>
<td>10.5 (4.2)</td>
<td>3.5</td>
<td>15</td>
</tr>
</tbody>
</table>

Table 2 Climbing Parameters of the Boys of the GJNT

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Mean (SD)</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Climbing grade (UIAA)</td>
<td>9.7 (0.45)</td>
<td>9.3</td>
<td>10.5</td>
</tr>
<tr>
<td>Years of climbing (y)</td>
<td>6 (2.1)</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>Training sessions per week</td>
<td>3.4 (0.9)</td>
<td>2</td>
<td>4.5</td>
</tr>
<tr>
<td>Training hours</td>
<td>12.8 (4.7)</td>
<td>7</td>
<td>22</td>
</tr>
</tbody>
</table>
Table 3  Means and Standard Deviations Between the Girls of the GJNT and Their Control Group and the p-Values of Their Differences

<table>
<thead>
<tr>
<th></th>
<th>Girls of the GJNT</th>
<th>Female Control</th>
<th>Significance (p-value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height (m)</td>
<td>161.6 (4.3)</td>
<td>167.5 (5.7)</td>
<td>0.05</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>50.3 (4.4)</td>
<td>56.5 (3.6)</td>
<td>0.02</td>
</tr>
<tr>
<td>BMI</td>
<td>19.3 (1.8)</td>
<td>20.1 (0.8)</td>
<td>0.32</td>
</tr>
<tr>
<td>Leptin (ng/ml)</td>
<td>2.9 (1.2)</td>
<td>5.3 (3.0)</td>
<td>0.08</td>
</tr>
<tr>
<td>Ghrelin (pg/ml)</td>
<td>1442.69 (562.49)</td>
<td>1035.42 (231.525)</td>
<td>0.13</td>
</tr>
</tbody>
</table>

Table 4  Means and Standard Deviations Between the Boys of the GJNT and Their Control Group and the p-Values of Their Differences

<table>
<thead>
<tr>
<th></th>
<th>Boys of the GJNT</th>
<th>Male Control</th>
<th>Significance (p-value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height (m)</td>
<td>174.9 (9.0)</td>
<td>177.3 (5.5)</td>
<td>0.50</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>61.3 (7.1)</td>
<td>69.7 (11.0)</td>
<td>0.08</td>
</tr>
<tr>
<td>BMI</td>
<td>20.1 (1.9)</td>
<td>22.2 (3.9)</td>
<td>0.15</td>
</tr>
<tr>
<td>Leptin (ng/ml)</td>
<td>0.5 (0.2)</td>
<td>1.9 (2.8)</td>
<td>0.16</td>
</tr>
<tr>
<td>Ghrelin (pg/ml)</td>
<td>1321.36 (464.09)</td>
<td>1097.11 (148.03)</td>
<td>0.19</td>
</tr>
</tbody>
</table>
boys and the girls were significantly lower than their respective control group (s. Figure 2). The mean differences of the fat mass between the GJNT and the control group only reached significance for the boys, girls showed a trend \((p = 0.48)\) to be lower (s. Figure 3). Leptin values were lower than the target values calculated using the estimated Tanner stages (s. Figure 4), but the results were only significantly lower in the female group, the boys only showed a tendency \((p = .159)\).

**Figure 2** — Mean ± SD for the skinfold thickness of the boys and girls of the GJNT in comparison with their respective control group (significant differences to the control group represented by *).

**Figure 3** — Mean ± SD for the fat mass for the boys and the girls of the GJNT with their respective control group.
Discussion

This study was intended to investigate the correlations between high-level sport climbing and the development of adolescents. We studied girls and boys of the German Junior National Team (GJNT) and compared them to a control group of physically active adolescents of the same age group.

In a first step we compared the climbing characteristics of girls and boys of the GJNT with each other. The boys climbed significantly better than the girls even though they had been climbing for a comparable length of time and that they spent about the same time for training per week. This finding is in accordance with the literature (25). Many climbers believe that a positive ape index, i.e., a greater arm span than body height, leads to a better climbing performance. However no study could objectify this believe (9,13). Watts et al. (24) suggest that an increased arms span to height measurement, called a positive ape index, in elite climbers may be a selective trait. The boys of the GJNT in this study did show a positive ape index but there was no correlation between ape index and climbing grade achieved.

High-level sports climbers are significantly shorter (13,25) than nonclimbers. This is believed to be a consequence of better performances with better biomechanical proportions and lower weight. The recorded heights in this study (girls: 161.4 cm, boys: 174.9 cm) are comparable to other studies on adults (13,25), but they were higher than in the study by Watts et al. (24), who investigated young climbers not having reached their final height yet. We therefore took a closer look at the SDS values to quantify the heights in relation to the normal collective. The SDS-values recorded in this study were not different from the standard population. Therefore we did not find our climbers to be exceptionally small in stature but rather of normal height. With regard to the question whether high-level sports climbing has negative effects on the growth of the adolescents, as observed in gymnastics
we can state that this does not apply to this group, as the DSDS values of the boys and girls of the GJNT were not significantly different from zero, meaning that they were growing as predicted by the height of their parents.

Another characteristic of sports climbers is their low body weight (24,25). The concern that young climbers may manipulate body mass to extremes to perform at a higher level has led the Austrian organization for climbing to adopt a set of minimum BMI standards for competitive climbers (16). Our collective was comparable to adults studied by Watts et al. (25), and had comparable BMI values to the adolescents studied by Watts et al. (24), the higher values recorded for weight in our study are therefore explainable by the difference in height. Concerning the SDS values, the group of the GJNT in this study the girls had significantly lower values for weight as well as for BMI. When compared with their control group the girls of the GJNT were significantly lighter but this did not show in the BMI, as they were also smaller than the control group. Therefore when compared with another physically active group, the girls were not exceptionally thin. In our opinion, a comparison of athletic children with the general population may be inappropriate and adapted SDS values need to be considered for better evaluation of physically active children. The boys were lighter and had a lower BMI with respect to their SDS values. However, none of the parameters reached significance. All the BMI values recorded in this study were well above the limits envisioned by the ÖSK and therefore it remains questionable whether such limits are even necessary.

It is interesting to note, that although the boys of the GJNT were not significantly different from their control group with respect to height, weight and BMI, they had a significantly lower fat mass determined by skinfold thickness (GJNT: 5.4 ± 1.1, control: 8.4 ± 2.8), as well as by body impedance (GJNT: .7 ± 3.9, control: 12.8 ± 6.4). The girls also had significantly lower skinfold thickness than their control group (GJNT: 7.0 ± 1.4, control: 9 ± 1.7), however the difference in fat mass, albeit lower than in the control group, did not reach significance (GJNT: 13.4 ± 5.2, control: 18.3 ± 3.2). These findings are comparable to the data from Watts et al. (24) even though the different measuring techniques make a direct comparison impossible. It also needs to be stressed that the skinfold thickness was only measured over the scapula which is a limitation in itself. There is a widespread believe among climbers that reduced body fat improves performance, even though this has never been shown (18). Still many elite climbers often have low levels of body fat (14,17,24,25,27). The estimated minimum amount of body fat in adults compatible with good health is 5% in males and 12% in females (1). The adolescents in this study had higher fat percentages than these minimum requirements. However, there are no reference tables available for the minimum fat percentages in growing young athletes.

We also studied leptin levels as mediator of long-term regulation of energy balance in both groups especially regarding the correlation to the physical development and constitution of the high level sport climbers. Leptin levels did not differ significantly from the control group. However, when calculating leptin levels in SDS, we found significantly lower leptin levels in girls and not in boys. This finding goes in line with the reduction of total fat mass in girls. Thus, we suggest that leptin levels should be adjusted for athletic children. The serum-level of ghrelin as a fast-acting hormone did not reach any significant difference in both groups. The subjects did not report any abnormal eating habits or caloric restrictions. A study
by Courteix et al. (6) report that hypoleptinaemia in rhythmic gymnasts might be related to direct osteogenic effects and indirect hormonal mechanisms including preservation of normal IGF and cortisol levels.

The climbers of the GJNT did not show any serious growth or hormonal abnormalities with regards to leptin and development.

References