GROWTH AND PRACTICE OF WEIGHTLIFTING AMONG YOUNG MALE ATHLETES

Ahmed Ridha YAHIA [1]; Yessine ARFA[2]; Fatma Zohra BEN SALAH[3]; Catherine DZIRI [4]

1.2 High Institute of Sports and Physical Education Ksar Said / Tunisia

3.4 Sciences University of BIZERTE / Tunisia

yessine arfa: yessinearfa@gmail.com

Abstract

By this study we aim to establish the relationship between the practice of weightlifting and osteological growth of young people. 303 male subjects participated in this study including 153 grouped in experimental group and 150 subject in the control group.

Anthropological measures were taken three times spaces of 6 months. These measures concern the size, sitting size, the thickness of the wrists and the thickness of the femurs.

The statistical treatment of the data using analysis of covariance revealed that the practice of weightlifting does not affect growth among young people. The differences were recorded at the level of the thickness of the wrists resulting from the joint adaptation has the technique of Olympic weightlifting movements.

Keyword: Growth, practice, weight lifting, young male, athletes.

1. INTRODUCTION:

The practice of weightlifting has always been prone to fears over its effects on the growth of young people. These fears emanate less scientific truths and prejudices. These prejudices come from both parents, doctors that of a majority of teachers and educators physical and sports... They assume that these kinds of sports are dangerous especially for children and young people who practise weightlifting at risk to see their growth hindered. **(Pierce et al., 2008)** suggests that the origin of these prejudices have been strengthened in 1983, when the American Academy of Pediatrics (American Academy of Pediatrics) who has published research giving a negative opinion on the practice of weightlifting, which has strengthened these prejudices more than two decades.

This research indicated including a negative impact of sports on the musculo-skeletal system: the risk of excessively hypertrophier muscles resulting in a loss of muscle qualities such as tone, flexibility and explosiveness, etc. Thus, this kind of sports makes slow muscles and which are converted after discontinuation of their fat, finding practice a maximum precaution for the practice of strength sports and weightlifting in preadolescents (Pierce et al., 2008).

Other studies have focused on the description of the evolution of the various characteristics of populations of non-sporting teens (Beunen. Malina, Van't Hof. Simons. Renson & Van Gerven, 1988; Lightweight and Lambee 1985) or youth participating in sporting activities in schools (Basel. Mayhew. Piper. Ball & Wiliman. 1992) these studies gave held contradictory and disparate results because they were made on various populations and practicing sports activities various and levels varied.

Several studies have shown the existence of a link between the practice of sport and osteological characteristics in adult athletes **(vaibhav et al. 2004 Jürimäe et al 2006)**. On the other hand, in this context, no studies have been carried out among young athletes, especially during puberty.

Although physical activity on a regular basis seems not affect growth in length of bone, changes to the level of the density. Thickening and mineralization were reported (**Bailey and McCulloch 1990; Booth and Gould. 1975; Cacciari et al., 1990; Malina, 1983**). This adaptation process is designed to preserve the integrity of bones often unsolicited. Response to mechanical stimulation of bone is subject to a threshold which differs according to the involved segment (**Smith and Raab, 1986**). Among players of tennis for example, several studies report observed differences in the thickness of the cortical area and dominating by comparison contra-lateral arm bone density (**Buskirk et al., 1956;) Huddleston et al., 1980; Jones et al, 1977**). It should be noted that these studies were conducted with adult athletes. The existence of this phenomenon in the young tennis player is poorly documented. **Sommer (1985)** however reports the same phenomenon at junior age players part of the German elite of tennis.

The appearance of the first signs of bone hypertrophy may seems to manifest itself as a teenager (**Bailey et al 1986**). All bony structures subjected to repetitive compressive tension react by this coping mechanism (**Steinhaus, 1933**).

The acquisition of bone capital depends on genetic factors that play a major role in the determination of peak bone mass. The hormonal status is the most important determinant of bone mass during growth and especially during puberty where the body undergoes significant variations in levels of anabolic hormones (**Lorentzon et al 2005).** Food is another environmental factor determining capital bone (**Rauch et. Al. 2004).** A correct ration of calcium is necessary to achieve the peak of bone mass predetermined genetically which allows to reduce the range of the subsequent risk of fractures and osteoporosis (**Braillon et al. 2006 Markou et al 2004**). Another factor for optimizing peak bone mass and which is considered as the most important environmental factor, it is physical activity (**Gustavson et al. 2003 Turner et al 2005**). This beneficial effect of exercise during the growth period is due not only to optimize bone mass but also its power to ensure a good quality and bone strength allowing him to be more resistant to any type of torsion (**Mackay et al 2005, Jakes et al 2001**). They seem interesting to know and to study, since they are modifiable factors, through which it is possible to increase bone accretion. Exercise can be considered as a preventive measure against bone fragility that may occur at the age adult (**Karlsson et al 2001).** It is a valuable adjunct to programmes aimed at reducing the risk of osteoporosis (**Rubin et al., 1993, Umemura et al 1997).** Links between physical activity, bone mineral density and growth hormones can be observed in different pubertal stages within the general population (**Yilmaz et al 2005**).

These studies have, therefore, finished to a lot more questions than answers. Indeed, what effect the practice of weightlifting has on the growth of young people? Are these effects vary according the periods of growth?

The stated hypothesis is that weightlifting practice has no negative effects on growth.

2. METHOD

PARTICIPANTS:

Our study was conducted on 303 young Weightlifters pre-pubescent and pubescent in consists of a sedentary school and an experimental group control group of young Weightlifters of same age form. We tried to make so that the control group came from the same cultural and especially socio-economic milieu as the experimental group, and to stabilize the effects of the different variations of environmental factors including social and socio-economic factors.

To this end, and to ensure a maximum of equivalence between the two groups, by reducing the maximum gap of views of secondary variables and after having eliminated the subjects who had not completed the three tests, our sample consisted of 303 subjects, distributed as follows:

Groups	Boys	
	G. experimental	Control group
11 and (-)	40	44
12	20	21
13	25	25
14	21	20
15	17	15
16	18	15
17	12	10
	153	150
Total	303	

INVESTIGATIVE TOOLS:

In accordance with the protocols of procedures we have measures three times 6 months following variables indicators:

1. Osteological length:

- Standing (cm),
- Seat height (cm),

2 Diameter Osteologique: index of the skeletal end robustness

- Wrist (cm) diameter,
- Humeral diameter (in cm),

PROCEDURE:

All measurements were performed according to standard procedures (Callauvway, Chumlea. Bouchard. Himes. Lohman. Martin, Mitchell. Mueller. Roche and Seefeldt, 1989; Hamson. Buskirk. Carter. Johnston. Lohman. Pollock, Roche and Wilmore. 1989; Wilmore, Frisancho. Gordon, Himes. Martin, Martorell & Seefeldt, 1989).

Subjects were also divided into three groups according to the age categories established by the Tunisian Federation of weightlifting, which coincides with the degree of biological maturation. To do this, the successful maturation index was age corresponding to the maximal short stature growth speed (AVM). The availability of longitudinal series for a large number of subjects has made it possible to estimate this index which is used in longitudinal studies **(Malina & Bouchard, 1991 a).**

Data were examined to see that the vast majority of subjects achieved their maximum growth rate for the size between the ages of 13 to 15 years, which is consistent with the given of **Sprynarova and Parizkova (1977)**

Subjects at the age of less than 13 years formed the prepubescent group within the meaning of the somatic maturation (GAVI), those aged between 13 and under 15 years of age were very active growth phase (AVM2) group and finally the third group (AVM3) consisted of athletes aged 15 years until 18 years of age, i.e. those who had completed their point of maximum growth.

Information thus collected were entered in a database under Excell then transferred has and statistical analysis SPSS 17.

Statistical analysis was performed by l use of analysis of covariance.

3. RESULTS:

MEASURES OF VARIATION OF THE STANDING HEIGHT

Among males aged 13

Table No. 8: Tests of the contrasts in groups of 13 boys

Source	FACTOR 1	Type III sum of squares	DF	Mean of the squares	F	GIS.
FACTOR	Linear	1.739	1	1.739	.928	.337
FACTOR * TD1	Linear	8.511	1	8.511	4,544	.035
FACTOR * GROUPS	Linear	2.209	1	2.209	1.179	.280
Error (factor)	Linear	222.923	119	1.873		

Table 8a: Tests of effects between the boys of 13 groups

Source	Type III sum of squares	DF	Mean of the squares	F	GIS.
Intercept	4.212	1	4.212	.481	.489
TD1	20647.711	1	20647.711	2.356E3	.000
GROUPS	202.147	1	202.147	23.064	.000
Error	1043.005	119	8.765		

The results above, found that both groups although they have suffered a growth at the level of the standing height, it remains non-significant to. 280, with a F = 1.179.

On the other hand, the improvement in the subjects in the experimental group is significantly higher than that of the control group, with a = 23.064 F, significant to. 001.

This, we can infer that the practice of weightlifting by youth aged 13 has a positive effect on the growth of the standing height. So on the different constituent segments this variable in this case the size of the trunk and lower limb.

Table No. 9 bis: Tests of effects between groups of boys-15 years					
Source	Type III sum of squares	DF	Mean of the squares	F	GIS.
Intercept	237.983	1	237.983	18.599	.000
TD1	11550.029	1	11550.029	902.644	.000
GROUPS	220.668	1	220.668	17.245	.000
Error	1126.028	88	12.796		

The above results to find:

On the one hand, that the two groups have noted a significant improvement at the level of the standing height variation, affirmed by an equal to 5.334 significant snedecor F. 023.

On the other hand, the improvement in the subjects in the experimental group is significantly higher than the control group, justified by a F = 17.245, significant to. 001.

This, we infer that,-15 years age group is characterized by a remarkable growth of the standing height, more the practice of weightlifting at this age, has a greater impact on this growth.

Among males aged 18

Table 10: Tests of contrasts in 18 boys groups						
Source	FACTOR 1	Type III sum of squares	DF	Mean of the squares	F	GIS.
facteur1	Linear	9.849	1	9.849	17.880	.000
facteur1 * TD1	Linear	6.745	1	6.745	12.245	.001
factor1 * group	Linear	11.251	1	11.251	20.426	.000
Error (factor1)	Linear	46.820	85	.551		

Table No. 10 bis: Tests of effects between groups of 18 boys					
Source	Type III sum of squares	DF	Mean of the squares	F	GIS.
Intercept	181.248	1	181.248	23.508	.000
TD1	6783.516	1	6783.516	879.841	.000
GROUP	78.360	1	78.360	10.164	.002
Error	655.345	85	7,710		

The results above listed, allowed us to see that both groups have suffered growth significant at the level of the standing height, with a F = 20.426, significant to. 001.

On the other hand, the improvement in the subjects in the experimental group is significantly higher than that of the control group,

Table n ° 11 bis: Tests of effects between the boys of 13 groups					
Source	Type III sum of squares	DF	Mean of the squares	F	GIS.
Intercept	44.193	1	44.193	6.767	.010
SAV	3984.626	1	3984.626	610.165	.000
GROUPS	109.452	1	109.452	16.760	.000
Error	777.118	119	6.530		

confirmed by a F = 10.164, significant at. 002.

These results allow us to deduce that,-18 years age category is characterized by outlet size, thus, the practice of weightlifting by athletes of same age, participates actively on the growth of the standing height. So on the different constituent segments this variable in this case the size of the trunk and lower limb.

MEASURES OF VARIATION IN SEATING SIZE

Among males aged 13

Table n ° 11: Tests of the contrasts in groups of 13 boys						
Source	FACTOR 1	Type III sum of squares	DF	Mean of the squares	F	GIS.
FACTOR	Linear	.402	1	.402	.276	.601
FACTOR * TA1	Linear	1,392	1	1,392	.955	.330
FACTOR * GROUPS	Linear	16.723	1	16.723	11.475	.001
Error (factor)	Linear	173.418	119	1.457		

The above results to find:

On the one hand, that the two groups have registered a significant improvement at the level of the seat size. Indeed F of snedecor equals 11.475, significant to. 001.

On the other hand, the improvement in the subjects in the experimental group is significantly higher than that of the control group, with a = 16.760 F, significant to. 001.

This, we can infer that the practice of weightlifting by young boys aged 13 has facilitator supplementation on the growth of the seat size, specifically on the size of the trunk, in this case on the vertebrae, so on the spine.

Thus, these results justify the standing height growth is caused through the evolution of the trunk, so the spine.

Under 15 years aged boys

Table n ° 12: Tests of the contrasts in groups of boys-15 years						
Source	facteur1	Type III sum of squares	DF	Mean of the squares	F	GIS.
facteur1	Linear	5.055	1	5.055	2,545	.114
facteur1 * TA1	Linear	1,988	1	1,988	1.001	.320
facteur1 * groups	Linear	2.013	1	2.013	1,013	.317
Error (facteur1)	Linear	174.796	88	1,986		

Table No. 12 bis: Tests of effects between groups of boys-15 years					
Source	Type III sum of squares	DF	Mean of the squares	F	GIS.
Intercept	107.108	1	107.108	21.014	.000
SAV	3381.806	1	3381.806	663.492	.000
GROUPS	62.689	1	62.689	12,299	.001
Error	448.534	88	5.097		

On the basis of the above results, we see that, although the two groups have registered an improvement at the level of the variation of the TA, this improvement is not significant to. 317, with a F = 1.013.

But, comparing the difference between the two groups, there is that the TA improvement subjects in the experimental group is significantly higher than the control group, certified by a F = 12,299, significant to. 001.

This, we to deduce that the significant growth of the TD is not visibly caused by the growth of the trunk, but appreciably by the growth of the lower limbs. And that the practice of weightlifting by age-15 years category, contributes to the growth of the seat size and more precisely of the spine.

Under 18 years old boys

Table n ° 13: Tests of the contrasts in 18 boys groups						
Source	FACTEUR1	Type III sum of squares	DF	Mean of the squares	F	GIS.
facteur1	Linear	3.429	1	3.429	8.988	.004
facteur1 * TA1	Linear	2.322	1	2.322	6.087	.016
facteur1 * group	Linear	1,988	1	1,988	5.210	.025
Error (facteur1)	Linear	32.426	85	.381		

Table n ° 13: Tests of effects between groups-18 years old boys					
Source	Type III sum of squares	DF	Mean of the squares	F	GIS.
Intercept	105.949	1	105.949	41.206	.000
SAV	1722.284	1	1722.284	669.838	.000
GROUP	3.448	1	3.448	1,341	.250
Error	218.552	85	2,571		

The above recorded results allow to note, that the two groups have recorded a significant improvement at the level of the seat size variation, shown by an equal to 5.210 Snedecor F significant at. 025.

While differentiation between subjects in the experimental group and the control group is not significant, affirmed by a F = 1.341, non-significant to. 250.

This allows us to predict that-18 years olds have suffered a significant evolution at the level of the seat size, but this developments is not at the origin of the practice of weightlifting.

MEASURES OF VARIATION IN THE DIAMETER OF THE WRISTS

Among males aged 13

Tests of the contrasts in groups						
Source	FACTOR	Type III sum of squares	DF	Mean of the squares	F	GIS.
FACTOR	Linear	164	1	164	6.385	.013
FACTOR * DP1	Linear	.051	1	.051	1.989	.161
FACTOR * GROUPS	Linear	.043	1	.043	1,679	.198
Error (factor)	Linear	3,060	119	026		

Tests of effects between groups					
Source	Type III Sum of Squares	DF	Mean Square	F	GIS.
Intercept	.949	1	.949	13.434	.000
DP1	43.644	1	43.644	617.943	.000
GROUPS	1.282	1	1.282	18,157	.000
Error	8.405	119	.071		

According the results listed above, with the diameter of the wrist, we found, that there is no difference in the two groups with a F = 1,679, non-significant. 198.

While the difference between the control and experimental group is significant at the.001 with a F = 18,157. What is to say that all the subjects in the experimental group underwent a significant development at the level of the wrist.

Which brings us to say that, although he y' has been an evolution in terms of the diameter of the wrist in two groups, remains non-significant variation, so that through the practice of weightlifting, the young athletes aged 13 undergo a most remarkable thickening of the wrist.

OLDER BOYS-15 YEARS

Tests of the contrasts in groups						
Source	FACTEUR1	Type III sum of squares	DF	Mean of the squares	F	GIS.
facteur1	Linear	.098	1	.098	4,938	.029
facteur1 * DP1	Linear	.032	1	.032	1.609	.208
facteur1 * groups	Linear	.001	1	.001	.051	.823
Error (facteur1)	Linear	1,744	88	.020		

Tests of effects between groups					
Source	Type III sum of squares	DF	Mean of the squares	F	GIS.
Intercept	2,789	1	2,789	28.528	.000
DP1	25.564	1	25.564	261.470	.000
GROUPS	.682	1	.682	6.980	.010
Error	8.604	88	.098		

According the results listed above, with the variation of the diameter of the wrists, we found, what he are no difference within the two groups, with a F of Snedecor equal to. 051, non-significant to. 823.

While the difference between the control and experimental group is meaningful to. 010, with a F = 6.980. What must be said, that all subjects in the experimental group underwent a significant development at the level of the wrist.

Which brings us to say, that the evolution of the diameter of the wrists is not representative, in the elderly-15 years, then this evolution is collectible in athletes of same age, confirming that the practice of weightlifting contributes positively to the thickening of the wrists of the Weightlifters of same age.

Among males aged 18

Tests of the contrasts in groups						
Source	FACTEUR1	Type III sum of squares	DF	Mean of the squares	F	GIS.
facteur1	Linear	.394	1	.394	14.305	.000
facteur1 * DP1	Linear	.492	1	.492	17.862	.000
facteur1 * group	Linear	.066	1	.066	2.390	.126
Error (facteur1)	Linear	2,339	85	.028		

Tests of effects between groups					
Source	Type III sum of squares	DF	Mean of the squares	F	GIS.
Intercept	.905	1	.905	12.835	.001
DP1	14.670	1	14.670	208.021	.000
GROUP	.497	1	.497	7.044	009
Error	5.995	85	.071		

According the results listed above, with the diameter of the wrist, we have not seen a difference within the two groups, confirmed by a F of Snedecor equal to 2.390, non-significant to. 126.

While the difference between the control and experimental group is significant for the first group. 009, with a F = 7.044. What is to say that all the subjects in the experimental group underwent a significant development at the level of the wrist.

This, we let’s say that developments registered in terms of the diameter of the wrists is not representative in 18 subjects, while the practice of weightlifting positively affects the development of the diameter of the wrist at this age.

THE HUMERAL DIAMETER VARIANCE MEASURES

AMONG MALES AGED 13

Tests of the contrasts in the groups						
Source	FACTOR	Type III sum of squares	DF	Mean of the squares	F	GIS.
FACTOEUR	Linear	.056	1	.056	2.985	.087
FACTOR * DH1	Linear	.017	1	.017	.900	.345
FACTOR * GROUPS	Linear	.044	1	.044	2.374	.126
Error (factor)	Linear	2.215	119	.019		

Tests of effects between groups					
Source	Type III sum of squares	DF	Mean of the squares	F	GIS.
Intercept	.674	1	.674	9.191	.003
DH1	50.497	1	50.497	688.111	.000
GROUPS	1.143	1	1.143	15.579	.000
Error	8,733	119	.073		

From the results above, exposing the humeral diameter, we have seen that it not are no difference within the two groups, with an equal to 2.374, not significant at F. 126.

While the difference between the experimental group and control has recorded a positive significant difference for the experimental group (F = 15.579, significant to. 001).

This, we can predict that, although not representative, the variation of the humeral diameter within the two groups practice of weightlifting by young athletes aged 13 influences the development of humeral diameter, therefore on the thickness of the arm, especially at the level of the end bottom of the bone and more precisely on the elbow joint. While the results have shown that the practice of weightlifting by young people under 15 years and over, had no effect on the diameter humeral, something that allows us to confirmed that the practice of weightlifting with charge, has no effect on the articulation of the elbows.

MEASURES OF VARIATION OF FEMORAL DIAMETER

AMONG MALES AGED 13

Tests of the contrasts in the groups						
Source	FACTOR	Type III sum of squares	DF	Mean of the squares	F	GIS.
FACTOR	Linear	.152	1	.152	3.135	.079
FACTOR * DF1	Linear	.031	1	.031	.642	425
FACTOR * GROUPS	Linear	2.014E - 5	1	2.014E – 5	.000	.984
Error (factor)	Linear	5.781	119	.049		

Tests of effects between groups					
Source	Type III sum of squares	DF	Mean of the squares	F	GIS.
Intercept	61.774	1	61.774	123.720	.000
DF1	57.837	1	57.837	115.835	.000
GROUPS	2,480	1	2,480	4.968	.028
Error	59.417	119	.499		

The results obtained at the level of femoral diameter measurement, show the two groups a non-significant difference. 984, with a F =. 001.

While the comparison of measurements of femoral diameter between the experimental groups than in the control group presented a significant difference, shown by a F of Snedecor equal to 4.968, significant at. 028.

This allows us to say that the growth variation of femoral diameter within the two groups is not significant]. growth is so normal, but by practicing weightlifting, the young athletes aged 13 undergo osteological development at the level of the thickness of the femur, which reflected the effect of the training, and especially the execution of technical movements, who plays on muscle contraction, in this case the Tibialis hamstrings and quadriceps that pull on the periosteum of the femur, causing thickening at the level of the diameter and the end of the femur. Thing that was not found among Weightlifters less 15 years and more, which allows us to predict that the practice of weightlifting with bottom-up charges, has no effect on the femoral diameter.

4. DISCUSSION:

Our study demonstrates also, and at the level of the variation of the speed of longitudinal growth of the skeleton, in addition to the significant variation in the TD, youth from 13 years old; the practice of weightlifting by boys, cooperated with the acceleration in the rate of growth of the TD for all age groups powerlifters, in a meaningful way, as it has been observed, among Weightlifters boys, that this variation was caused by growth of the spine for older lifters under 13 years and by the growth of the lower limbs in the group under 18 years. This confirms the law of alternation of Godin (1935).

Our study similarly affected bone diameters variation, which is an index of skeletal robustness of the ends. Statistical results, have asserted that the practice of weightlifting by boys aged under 13 years contributes to the development of DP as well as the development of DH and the DF. This implies that the practice of weightlifting by young people under 13 years old has an effect on joint modeling and therefore the thickening and the density of the bones.

As a result, the practice of this sport, developing the robustness of the ends bones, and especially the most important joints, which cited the articulation of the wrist, elbow, knee, and as we saw previously the variation in growth of the shoulder joint; This confirms Act scope that corresponds to the range of joint motion proportional to the difference of extent of the two surfaces. While from the age of 13, there was difference at the level of the RFP and only for practitioners of weightlifting, while at the level of the DF, the difference is not significant, therefore evolution is normal and is not influenced by the practice of weightlifting.

As a result, can say that the growth of diameter of bones and especially the ends, therefore joints, is essentially caused by the handling and execution of the technical gestures, but not by the lift of the load. Thing that contradicts the prejudices who claim that weightlifting deforms the bones and demolished the joints.

5. CONCLUSION:

This study allowed to highlight that contrary to received ideas weightlifting practice promotes bone development in the longitudinal direction however only the bones of the wrist have recorded significant variations might be the result of a joint adaptation to technical movements of weightlifting and not the load lift.However this study does not deal with the excessive practice of weightlifting that like any sport excesses cannot lead that has negative effects on the health. For this we recommend that any sport must be accompanied by monitoring carefully the different parameters of growth and this side measurements of physiological indices usually practical in high level athletes.

6. REFERENCES:

Bailey, DA. and McCullodr, R.G. (1990). Bone tissue and physical activity. Can. J. Spt Sci. 15: 229239.

Bailey. DA., Malina, R.M. & Mirwald; R.L (1986). Physical activity and growth of the child. In: F. Falkner and J.M. Tanner (4s.). Human Growth, wl. 2, chap. 7, pp. 147-170. Plenum Press. New Yok

Bailey, DA., Malina, R.M. & Rasmussen, R.L (1978). The influence of exercise, physical activity, and athletic performance on the dynamics of human growth. In: F. Faulkner, J.M. Tanner, J.M. (eds.), Human Growth, vol. 2: The Postnatal Growth, chap. 17, pp. 475-505. Plenum Press. New York

Bale. P., Mayhew, J.L. Piper, F.C., Ball, T.E. and Willman, M.K. (1992b). Biological and performance variables in relation to age in male and female adolescent athletes. J. Sports Med. Phys Fitness. 32: 142-148.

Bell, W. (1993). Body size and shape: a longitudinal investigation of active and sedentary boys during adolescence. J. Sports Sci. 11: 127-138.

Beunen, G.P., Malina. R.M., Van't Hof. MA., Simons. J., Ostyn. M., Renson. R. and Van Gerven, d. (1988). Adolescent growth and motor performance: a longitudinal study of Belgian boys. Champaign. 11. Human Kinetics.

Blimkie, C.J.R., Ramsey, J., Sale, D.G., MacDougall, J.D., Smith, K. and Gamer. S. (1989). Effects of 10 weeks of training on strength development in prepubertal boys. S.Oseid and KH. Carlson (eds). In: Children and exercise XIII: international series on sport sciences.Champaign, 11. Human Kinetics. 183-197.

Booth, F.W. and Gould, EW. (1975). Effects of training on disuse on connective tissue. Exerc. Sport Sci. Rev. 3: 83-112.

Borer, KT. (1995). The effects of exercise on growth. Sports Med. 20: 375397.

Brook, C.G.D. (1978). Cellular growth: adipose tissue. In: F. Falkner and J.M. Tanner (eds). Growth, vol 2. New York. Plenum Press. 475-505.

Cacciari E., Mazzanti L., Tassinari D., Bergamaschi R., Magnani C., Zappulla F., Nanni G., Cobianchi C., Ghini T.,Pini R. et Tani G.. (1990) effects of sports (football) on growth: auxological, anthropometric and hormonal aspects. Journal of applied Physiology 61:149-158.

Carter, J.E.L. Ross, W.D., Aubry, S.P., Hebbelinck, M. and Borms, J. (1982). Anthropometry of Montréal Olympic athletes. J.EL Carter (ed). In: Physical structure of Olympic athletes. Dart I: The Montréal Olympic games anthropological project Basel. Karger. 25-52.

Cabroi C. Anatomie-tome1 Appareil locomoteur (2ième éd. 10ième tirage). Edition française dirigée par C.CABROI. éd Flammarion Médecine-Sciences. 1992

Crawford, S.M.(1996). Anthropometry. D. Docherty (ed). In: Measurement in pediatric exercise science. Champaign. 11. Human Kinetics. 17-86.

Danowski R.G, Chanussot J.C. Traumatologie du sport (5ème éd). Ed Masson Paris. 1996.

Docherty, D. (1996). Measurement in pediatric exercise science. Champaign. 11. Human Kinetics.

Duche, P.. Falgairette. G.. Bedu. M.. Lac, G. 8 Coudert, J. (1993). Analysis of performance of prepubertal swimmers assessed from anthropometric and bioenergetic charaderistia. E uJ~. P hpbI. 66: 467-471.

Frost H. On our age-related bone loss; insights from a new paradigm.J. Bone Miner Res, 1997; 12:1539-46.

Gonyea, W.J. (1983). Skeletal muscle growth induced by strength training. KT. Borer. D.W. Edington and T.P. White (eds). In: Frontiers of exercise biology. Champaign. 11. Human Kinetics. 15-26.

Gustavson A, Thorsen K, Nordstrom P. A 3-year longitudinal study of the effect of physical activity on the accrual of bone mineral density in health adolescent males. Calcif Tissue Int 2003; 73: 108-114

Hale, C.J. (1956). Physiological maturity of lie league baseball players. Res. 0. 27(3): 276- 284.

Hamill B.P. Relative safety of weightlifting and weight training. J. Strength Cond. Res. 8:53–57. 1994.

Hind K, Burrows M. Weight-bearing exercise and bone mineral accrual in children and adolescents; a review of controlled trials. Bone 2007; 40:14-27.

Kannus P., Haapasalo H., Sankelo M., et al. Effect of starting age of physical activity on bone mass in the dominant arm of tennis and squash players. Annal Intern Medical 1995; 123: 27-31

Karlsson K M, Karrison C, Ahlborg H G, Valdimarsson O and Obrant K J. Bone turnover response to changed physical activity. Calcif Tissue Int 2003; 72: 675-680

Lane N.E., Bloch D.A., Hubert H.B. et al. running, osteoarthristis, and bone density: initial 2-year longitudinal study. Am J Med 1990; 88: 452-459?

Lohman, T.G., Roche, A.F. and Martorell, R. (1988).Anthropometric standardization reference manual. Champaign. 11. Human Kinetics.

Lorentzon M, Mellström D, Ohlsson C. Age of attainment of peak bone mass is site specific in Swedish men-The GOOD study. J Bone Miner Res. 2005 Jul; 20(7):1223-7.

Lowrey. G.H. (1986).Growth and development of children. Chicago, Year Book Medical.

MacDougall, J.D., Wenger, HA. ET Green, H.J. (1988).Evaluation physiologiques de I'athlete de haut niveau. Montréal. Dicarie Vigot.

Maimoun et al. 2004, Jurimae et al. 2006

Malina, R.M. (1994a). Attained size and growth rate of female volleyball players between 9 and 13 years of age. Ped. Exer. Sci. 6: 257-266.

Malina, R.M. (1994b). Physical activity and training: effects on stature and adolescent growth sport Med. Sci. Spotts Exer. 26: 759-766.

Malina. R.M. & Bouchard. C. (1991a). Biological maturation: Concept and assessment In: Growth, Maturation, and P h y s i c a I A ~c,h ap. 15. pp. 231-249. Human Kinetics Publishers. Inc Champaign. Illinois.

Malina. R.M. & Bouchard, C. (1991b). Genetic regulation of growth, maturation, and performance. In: Growth, Maturation, and PhyyYYcaIAciiviciyh,a p. 19, pp. 305328. Human. Kinetics Publishers, Inc Champaign. Illinois.

Malina. R.M. (1988). Competitive youth sports and biological maturation. EW. Bnnn and C.F. Branta (Eds.). In: Competitive Sports for Children and Youth: a OveNiew of Research and Issues, pp. 27-24. Human Kinetics Publishers. Inc Champaign. Illinois.

Malina. R.M. (1986). Maturational considerations in elite young athletes. J.A.P. Day (Ed.). In:Perspectives in Kinanthropornetry.The 1984 Olympic Scientific Congress Pmcedings.MII, p p. 29-44. Human Kinetics Publishers, Inc. Champaign, Illinois. 73

Malina, R.M. (1984). Physical growth and maturation. J.R. Thomas (4). In: Motor development during childhood and adolescence. Minneapolis. Burgess. 2-26.

Malina. R.M. (1983). Human growth, maturation, and regular physical activity. Acta Med. Auxol. 15: 5-27.

Malina. R.M.. Bouchard. C.. Shoup. R.F. Demijian, A. 8 Lariviere. G. (1982). Growth and maturity status of Montreal olympic athletes less than 18 yean of age. In: Medicine Sport. Vol. 16. chap 8. pp. 117-127. Karger. Basel.

Malina, R.M. (1980). Physical activity, growth, and functional capacity. EL Johnson. A.F. Roche and Suzanne (eds). In: Human physical growth and maturation: methodology and factors. New York Plenum Press. 303-327.

Malina. R.M. (1978a). Secular changes in growth. Maturation, and physical performance. Ex.Sport Sci. Rev. 6: 203255.

Malina. R.M. (1978b). Growth, physical activity and performance in an anthropological perspedive. F. Landry et W.A.R. Orban (eds.). In: Physical Adhdyand Human WelLBeing. Miami. Symposia Specialists, pp. 328.

Markou K.B., Mylonas, Theodoropoulou A., Kontogiannis A., Leglise M., Vagenakis A.G et Georgopoulos N.A. (2005). The influence of intensive physical exercise on Bone acquisition in Adolescent Elite Female and Male Artistic Gymnasts. Tha journal of Clinical Endocrinology & Metabolism 89 (9): 4383-4387.

Martin, AD. and Ward, R. (1996). Body composition. D. Docherty (ed). In: Measurement in pediatric exercise science. Champaign. II., Human Kinetics. 87-128.

Mclean, B.D. and Parker, A.W. (1989). An anthropometric analysis of elite Australian track cyclists. J. Sports Sci. 7: 247-255.

Rarick, G.L (1960). Exercise and growth. R. Johnson and ER. Buskirk (eds). In: Science and medecine of exercise and sport. New Yok Harper and Row. 440-465.

Rauch Frank, A. Bailey Donald, Baxter-Jones Adam, Mirwald Robert and Faulkner Robert. The “muscle-bone unit” during the pubertal spurt. Bone 2004; 34: 771-775.

Rougier, G. (1982). Repercussions des exercices physiques sur la croissance osseuse et staturale. Medecine du sport. 56: 2633.

Röthing, P. *(Red.)*. Sportwissenschftliches Lexikon. Hofmann, Schorndorf 1983

Rubin C. T, Lanyon L.E. Osteoregulatory nature of mecanical stimuli: Function as a determinant for adaptative remodelling in bone. J Orthop Res 1987; 5: 300-310

Shephard, R.J. (1984). Physical activity and child health. Sports Med. 1: 205-233.

Shephard, R.J. (1982). Physical activity and growth. Chicago. Year Book Medical.

Sommer, H.M. (1985). The influence of exercise and training on the locomotor system of children: a longitudinal study of adolescent tennis players. RA. Binkhorsf H.C.G. Kemper and W.H.M. Saris (eds). In: Children and exercise XI: international series on sport science. Champaign, 11. Human Kinetics, 308-318.

Sprynarova, S. et Parizkova. J. (1977). La stabilité des différences interindividuelles morphologiques et cardiorespiratoires chez les garçons. H. Lavall& et R.J. Shephard (eds.). In: Limites de la Capacité Physique chez l'enfant: Sciences de L'activité Physique, pp. 131-138. Edition du Pelican.

Tanner J M. (1962).Growth at adolescences (2nd Ed) Oxford: Blackwell 1962; 1-212.

Vicente-Rodriguez G, Ara I, Perez-Gomez J, Serrano-Sanchez JA, Dorado C, Calbet JA. High femoral bone mineral density accretion in prepubertal soccer players. Med Sci Sports Exerc 2004a; 36:1789-795.

Vicente-Rodriguez G, Dorado C, Perez-Gomez J, Gonzalez-Henriquez JJ, Calbet JA. Enhanced bone mass and physical fitness in young female handball players. Bone 2004b; 35(5):1208-15.

WEINEK. Biologie du sport. 1986

Wittich A, Mautalen CA, Oliveri MB, Bagur A, Somoza F, Rotemberg E. Professionel football (soccer) players have a markedly greater skeletal mineral content, density and size than age-and BMI-matched controls. Calcif Tissue Int 1998; 63:112-17.

Yïlmaz D, Erosy B, Bilgin E, Gümüser G, Onur E, Dundar Pinar E. Bone mineral density in girls and boys at different pubertal stages: relation with gonadal steroids, bone formation markers, and growth parameters. J Bone Miner Metab 2005; 23:476-482.