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Effects of Body Build on Metabolic and Physiological Function in Men and Athletes*

– 1. Especially on the Metabolic Function –

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ABSTRACT

The aim of this study was to investigate influence of body build on body composition, energy metabolic state and insulin concentration of blood. 29 male athletes and 36 male non-athletic students were recruited for the study. Anthropometry including chest depth and breadth, fat mass, fat free mass, tricep skinfold thickness were measured. Fasting glucose, lactate, triglyceride, free fatty acid, and insulin concentration in serum were measured. Body build was assessed using metric index, which calculated by regression equations of Mohr and Greil. The athletic and non-athletic students were allocated to 3 body build, that is leptomorph, mesomorph, and pyknomorph. Resting metabolic rate was calculated. Respiratory quotient was determined through ratio of measured VO_2 and VCO_2. Most non-athletes have a leptomorphic body build, in contrast to athletes mesomorphic type. The body build type influenced body composition differently between non-athletic group and athletic group. Weight, body mass index, body fat mass and fat mass proportion (%), and fat-free mass increased from leptomorph to pyknormorph in non-athletic group. Pyknormorphic athletes have a significant higher body mass index, fat mass, fat free mass than other body build type. Serum glucose, triglyceride, lactate, insulin showed significant differences only in non-athletic group between leptomorph and mesomorph. RMR increased significantly from leptomorph to mesomorph in non-athletes. There was no significant difference of RQ among 3 body build types in both athletes and non-athletes. This study gives a coherent data on body build and body composition for athletes and non-athletes students. The influence of body builds on energy metabolic status of serum was different between athletes and non-athletes.

KEY WORDS: metric index, body build, body composition, energy metabolism.

INTRODUCTION

In order to decrease the risk of chronic cardiovascular disease due to overnutrition, indices of weight relative to height are extensively used in clinical and epidemiological practice as indicator for obesity and guides for ideal body weight. Broca index, height-weight table and their normogram, and body mass index are especially used in clinical and epidemiological nutritional assessments. But these indices do not consider the effects of body build variability, resulting in the problem of under- or overevaluation of body weight. Therefore, studies investigating the association of obesity with cardiovascular disease showed conflicting results.[1-3] The inconsistency of findings may have been due to the in ability to identify correctly those obese people who are at particularly high risk for developing consequential diseases.[4] Various anthropometric parameter being relevant for nutritional status showed clearly an association with body build type.[5)6] Therefore, in addition to descriptors of body composition and fat distribution, the influences of body build on chronic disease were considered in studies.[7-10] Investigations into the relationship between disease and physique showed an association of lateral body build and cardiovascular disease as compared to linear body build.[7-9]

The first inclusion of body build in nutritional assessment was Metropolitan height-weight table.[11] However, the method used to allocate people into three different frame size was not described in the Metropolitan table.[12] This shortcoming continuously presents a major conceptual problem in the determination of frame size. Few investigations involving the assessment of frame size actually defined this problem. According to Himes and Frisancho,[13] as descriptor of body build or frame size, the following definition can be used: Body build is more a concept than a

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specific measurement. It encompasses bone, joint and skeletal breadths and depths that are representative of the supportive structure as a whole.

Most studies have therefore selected skeletal measurements, like bone breadth, length, and depths as measures of body build. Skeletal dimensions are considered to be important estimators of fat-free mass, as the skeleton is a chief component of fat free mass and is also a good predictor of muscle mass. The bony dimensions, used in determining body build, includes an regression equation of sum of bitrochantric and biacrominal breadths on height[14] and regression equations of height, bony chest breadth and depth[5)15] named as metric index, bony chest breadth,[16] an index of height divided by wrist circumferences,[17] the sum of a series of bone breadths, lengths, and depths.[18]

As a classifier of body build type into linear and lateral body builds, the Metric index, which was defined first by Strmgren[19] and further developed by Conrad[20] has proved to be practical especially for bony dimension.[6] It was also proven to be associated with nutritional status. Determining Metric index is relatively easy; it is regression equations composed with only 3 body measurements of height, chest breadth (transversal thorax diameter), and chest depth (sagitaler thorax diameter) which are easily measurable. It is applicable not only to adults, but also to children.[5)6]

Investigation on energy metabolic state or risk of cardiovascular disease and relative fatness for adults, including influences of body build type in respect to bony dimension, is non-existent among Korean subjects. As a indicator of body build, Korean studies used mostly not the bony dimension in nutritional assessment, but the relative fatness to height.[21)22] As a result, influences of body build on relative fatness is not in itself investigated among Korean subjects.

Recently, it is reported that obesity among young people has increased and the risk factor of cardiovascular disease is rising in young adult. As relative fatness is known to be associated with body build,[6)8)10] the energy metabolic state in young people could be different among different body builds. Athletes are known to have generally different body builds and compositions at the same relative weight as compared to normal adults with no vigorous exercise. Therefore the effect of body build on energy metabolic state could be different between athletes and non-athletic adults.

This study is a preparation for future studies on the relationship between body build type and nutritional state or risk factors for cardiovascular disease in Korean people. The influences of body build, as determined by metric index values, on energy metabolism of young male adults and elite judo athletes were stressed.

The purpose of the present study were as follows: 1) to investigate the relationship between body build predicted by Metric index and body composition in athletic and non-athletic groups, 2) to investigate the influence of body build on insulin concentration, a chief hormone regulating energy metabolism, and on carbohydrate and fat metabolic state in blood, 3) to investigate the effect of body build on respiratory quotient as metabolic indicators of carbohydrate and fat oxidation proportion in non-athletes and athletes.

SUBJECTS AND METHODS

1. Subjects

The recruited subjects in this study were 30 male judo athletes and 36 nonathletic healthy college students aged 19 to 28 years. The athletic group was composed of elite judo athletes who trained regularly for longer than 6 hours per day, 6 times per week.

2. Measurement of anthropometric variables and repiratory quotient

Anthropometric measurements were performed with the subjects wearing light underwear using instruments under permanent precision control by a trained interviewer. Body weight was measured with an scale accurate to 100 g; height was measured to the nearest 0.1 cm using a flexible anthropometer. Chest breadth and chest depth were measured with a large spreading caliper to the nearest millimeter in the stationary phase between inspiration and expiration. With the subjects standing in natural position, chest breadth measurement was performed on the sixth rip in the midaxillary line. Chest depth was measured in the same position with the tips of the caliper at the forth coststernal junction and the spinous process of the vertebra in the same horizontal plane. Tricep skinfold thickness was measured using a Lange caliper to the nearest millimeter according to the instructions of the anthropometric manual.[23] Body composition parameters including body fat mass and proportion (%) were measured using an instrument based on bioelectrical impedence (Tanita, TBF 105, Japan).

Metric index was used as a measure of body build, describing the relation of body height as a descriptor for vertical growth tendency to dimensions of the skeletal chest as a descriptor for the horizontal growth tendency. Metric index was calculated according to the regression formula by Greil[15] using height, chest breadth, and chest width. Body build types were assessed according to Greil[15] using Metric index values. Body build type can be allocated into pyknomorph, mesomorph, and leptomorph. The allocation of subjects into 3 different body build types were described in detail in study of Johnson and Scholz.[6] Resting metabolic rate was calculated according to Harris and Benedict[24] using weight, height, and age. Respiratory quotient was measured in resting fasting state using gas analyser (Quinton 4300, USA).

3. Blood analysis

Fasting blood was taken from anticubital veins of subjects. Serum samples, obtained bv centrifugation at 2000 rpm for 10 minutes, was frozen at −32℃ until further analysis. Serum glucose, triglyceride, and lactate were measured using a commercial kit (DT 60, Johnson and Johnson Co., USA). Serum free fatty acids was analyzed with a kit (Wako Co., Japan) using a spectrophotometer. Serum insulin was analyzed by an enzyme-linked two site immunoassay.[25]

4. Statistical analysis

Data was expressed as the mean with standard deviation. Statistically significant mean differences between non-athletic and athletic group were evaluated primarily by Students t-test. All data analysis between different body builds was conducted separately in non-athletes and athletes using a generalized linear model (GLM) and compared using the least square difference method. Statistical analysis was basically performed by using the Statisticial Analysis System.[26]

RESULTS AND DISCUSSION

This study investigated the relation between body build using metric index and body composition and energy metabolism indicators. Difference in these variables between non-athletes and athletes was primarily analyzed.

The general characteristics of study participants are described in Table 1. Body mass index of the subjects on average lay in the normal range, but showed a broad distribution from a lean type to grade 1 obesity.[27] Metric index ranged from close to −2, depicting a leptomorphic or tall and slim body build, to values close to 1.5, depicting a pyknomorphic or short and thick body shape.

Table 1. General characteristics of subjects (n = 65)(Mean ± SD)

Variables	Subjects	Range
Height (cm)	174.3 ± 7.0	155.0 − 196.0
Weight (kg)	75.3 ± 16.0	50.0 − 130.8
Age (years)	22.3 ± 2.0	19 − 28
BMI (kg/m^2)	24.7 ± 4.7	18.1 − 43.2
Metric index	0.712 ± 0.697	−2.14 − 1.5

Table 2. Comparison of anthropometric variables between non-athletes and athletes(Mean ± SD)

Variables	Non-athletes (n = 36)	Athletes (n = 29)	Significance
Height (cm)	175.3 ± 6.2	173.3 ± 7.8	NS
Weight (kg)	69.8 ± 13.1	82.2 ± 16.9	**
BMI (kg/m^2)	22.6 ± 3.3	27.3 ± 4.8	**
Fat free mass (kg)	55.5 ± 7.3	69.0 ± 10.4	***
Fat mass (kg)	14.3 ± 6.7	13.2 ± 7.7	NS
Fat mass (%)	19.6 ± 5.4	15.3 ± 5.5	*
TSF (mm)	9.7 ± 3.4	9.6 ± 6.2	NS
Chest depth (cm)	18.2 ± 2.6	21.2 ± 2.70	***
Chest breadth (cm)	27.9 ± 2.7	30.3 ± 3.20	**
Metric index	−1.086 ± 0.61	−0.246 ± 0.49	***

*: significant at $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$
NS: not significant, TSF: tricep skinfold thickness

1. Comparison between non-athletes and athletes

Comparison of anthropometric variables between non-athletes and athletes is described in Table 2. There were no differences in height and tricep skinfold thickness between non-athletes and athletes. Athletes had significantly higher values of body weight, body mass index, fat-free mass than did non-athletes. But fat mass and body fat percentage of athletes were lower than in non-athletes. The athletic group was assessed to be in grade 1 obesity[27] by BMI using as relative obesity indicator and is thicker than non-athletes. But body fat mass proportion of athletes was only 15%, showing an optimal level,[27] as a result of a long term physical training. In contrast, mean of non-athletic group lied in optimal niveau by BMI, but showed by body fat proportion slightly overfat niveau.[27]

Difference between Chest depth and breadth in athletes were higher than in to non-athletes. Non-athletes had a mean Metric index of −1.086, indicating a tendency towards a leptomorphic type, but athletes had a mean Metric index of −0.246, indicating a mesomorphic type.

Fasting glucose, triglyceride, free fatty acid, lactate concentrations in serum, and fasting insulin concentration of athletes and non-athletes are listed in Table 3. Average serum glucose and triglyceride concentrations in both group were in the normal range. Athletes had significantly higher serum glucose. Athletes have in general a lower insulin content as compared to non-athletes. Insulin release from pancreas is well known to be regulated mainly by blood glucose concentration. In contrast to the difference of glucose concentration between both groups, the insulin concentration was, although not significant, slightly lo-

Table 3. Comparison of fasting serum glucose, triglyceride, free fatty acid, lactate and insulin concentrations between non-athletes and athletes (Mean±SD)

Variables	Non-athletes	Athletes	Significance
Glucose (mg/dl)	85.1 ± 14.8	98.6 ± 15.6	***
Triglyceride (mg/dl)	86.5 ± 37.1	93.8 ± 56.9	NS
Free fatty acid (μEq/l)	457.1 ± 257.2	316.1 ± 184.2	*
Lactate (mMol/l)	3.18 ± 1.28	2.21 ± 0.64	***
Insulin (μU/ml)	10.9 ± 7.8	10.4 ± 11.7	NS

*: significant at $p < 0.05$, ***: $p < 0.01$
NS: not significant

wer in the athletes than non-athletes. It was reported that physical training can decrease glucokinase and hexokinase activity and lower activity of the sympathetic nerve system, resulting in a low blood insulin state.[28] Therefore, a higher level of glucose in athletes of this study can attribute to lower insulin level due to long-term training.

The triglyceride content showed no difference between both groups and was in the normal range. Athletes had significant lower concentrations of lactate and free fatty acid than to non-athletes. Lactate concentration in blood and muscle is known to reflect anaerobic metabolism and muscle fatigue status. Such lower level of fasting serum lactate seemed rather to reflect lower glycolysis. Physical training and exercise is known to improve cardiovascular function and increase the activity of hormone-sensitive lipase. Furthermore, insulin is well known to inhibit hormone-sensitive lipase and restrict release of free fatty acid from adipose tissue. The lower concentration of insulin in athletes seems to cause a fast release of free fatty acid as an energy source in tissues like muscle for physical training. As a result, release of free fatty acid is increased by exercise, so a higher level of serum free fatty acid was observed in other study. However, the uptake of free fatty acid into various tissues is proportional to its blood concentration.[29] Free fatty acid is well documented to be used as the main energy source in endurance exercise. The higher uptake of free fatty acids into muscle than the release from the adipose tissue in athletes or preferential use of free fatty acid than glucose as a energy source could result in a reduced level of free fatty acids in athletes in this study.

Resting metabolic rate (= RMR) and respiratory quotient (= RQ) of both groups are compared in Table 4. Athletes had a higher resting metabolic rate, indicating a higher basal metabolic rate than non-athletes. It is well known that basal metabolic rate is dependent on the active cell mass, such as muscle mass and skeletal mass. In this study, the resting metabolic rate was not measured, but calculated using body weight and age. Hence, the higher values for resting metabolic rate of athletes seemed to reflect not only higher fat-free mass, but also body weight of athletes. Respiratory quotient showed no significant difference between the non-athletic and athletic groups. Mean of respiratory quotient of both groups are, respectively, ca. 0.75, indicating a high proportion of fat oxidation compared to general RQ value of 0.85.[30] Because in this study the RQ was measured in fasting state, free fatty acids may have been used as the main energy source rather than glucose in both study subject groups, resulting in a low RQ value.

Table 4. Resting metabolic rate (RMR) and Respiratory quotient (R.Q) of athletes and non-athletes

Variables	Groups		
	Non-athletes	Athletes	Significance
RMR (Cal/day)	1550 ± 35	1672 ± 171	NS
R.Q	0.75 ± 0.12	0.75 ± 0.08	NS

**: significant at $p < 0.01$, NS: not significant

Table 5. Distribution of body build and metric index in athletes and non-athletes n (%)

Build	Groups			
	Total	Non-athletes	Athletes	χ^2
Leptomorph	33 (53.8)	31 (86.1)	2 (6.9)	
Mesomorph	27 (41.5)	4 (11.1)	23 (79.3)	38.459***
Pyknomorph	5 (7.7)	1 (2.8)	4 (13.8)	

***: significant at $p < 0.001$

2. Distribution of body build in non-athletes and athletes

The study subjects were allocated to 3 different body build using metric index. The body shape distribution of non-athletes and athletes is shown in Table 5. The leptomorphic body shape, indicating generally a tall and slim body build, was shown in 86% of the non-athletes. In contrast, 79% of athletes showed a mesomorphic body shape, mainly indicating a mid-type between a tall and slim, and a short and thick body shape. The pyknomorphic non-athlete category included only one person.

3. Influences of body build in non-athletes and athletes

To examine influences of body build on body composition and energy metabolic status of non-athletes and athletes, all anthropometric variables, serum energy metabolic substrate, RMR, and RQ were categorized by body build type separately in non-athletes and athletes.

Means of height, weight, tricep skinfold thickness (TSF), chest depth, breadth and metric index in different body builds of non-athletes and athletes are listed in Table 6. Height, weight, TSF, chest depth, and chest breadth of non-athletes showed difference, increasing from leptomorphic to pyknomorphic type. Athletes have, in contrast to non-athletes, a highest height in leptomorphic body build compared to other body builds, but did not showed any form of dependence on the body build. Weight, TSF, and chest depth of non-athletes increased significantly from leptomorphic to pyknomorphic type, so athletes of pyknomorphic shape have also highest values of anthropometric variables except height as compared to other body build types. Chest depth and Metric index increased from leptomorph to pyknomorph in the athletes and non-athletes.

Body mass index, fat-free mass, fat mass, and body fat proportion (%) in different body builds are shown in Fig. 1. These anthropometric variables in non-athletes increased significantly from leptomorph to pyknormorph. Chest depth and breadth were used in this study as components for determination of body build. Chest breadth is reported to be a good estimator of frame size.[31] The pattern of body composition by body build types correspond exactly to that of chest size variables, indicating an association of body build with body composition. An positive association of body bony diameters including chest size or body build with body fatness in people without vigorous physical activity was also reported in other studies.[5,18,32] In athletes, anthropometric variables including BMI and body composition, were larger in pyknormorph as compared to leptomorph and mesomorph body builds. The smallest body fat percentage as like chest breadth is found in mesomorph. From this outcome, there seems to be a deep relationship between body fat accumulation and chest breadth in judo athletes.

Serum concentration of fasting glucose, triglyceride, free fatty acid and lactate, and insulin are listed in Table 7. Insulin concentration in non-athletes showed significant differences among different body build types. Leptomorphs showed, however, lower values than other body build types. Leptomorphic athletes also showed, lower values than other body build types, but this difference was not statistically significant. It is well known that after weight reduction, the insulin sensitivity for blood glucose is increased, while the insulin requirement is reduced. It is also reported that body fat mass and blood insulin concentration are positively associated.[33] Hence, it could be supposed to be a lower insulin secretion from pancreas in body build types with lower fat accumulation in both groups compared to the other body builds. The insulin concentration in athletes was lower than in non-athletes in all the body build groups. This was probably because of high glucose uptake into the muscle[34] and of a lower release of insulin from pancreas as a result of low sensitivity of insulin to blood glucose[35] from long-term physical training.

The serum glucose concentration of non-athletes showed no significant difference according to body build. The leptomorph have, however, rather lower glucose level. This pattern should be associated with lower fat accumulation, resulting in a lower level of insulin concentration in this body build.[33] The lactate, triglyceride and free fatty acid content in serum showed, in contrast, the highest values in non-athletic mesomorph than in other body builds. However, the mean values of these metabolic parameters

Table 6. Comparison of anthropometic variables among different body builds of non-athletes and athletes (Mean + SD)

Variables	Body build		
	Leptomorph	esomorph	Pyknomorph
Height (cm)			
Non-athletes	174.3 ± 5.8[a]	180.5 ± 6.5[b]	185.0 ± 0.0[c]
Athletes	184.0 ± 17.0[a]	172.0 ± 7.0[b]	175.0 ± 4.1[a]
Weight(kg)			
Non-atheltes	66.3 ± 8.3[a]	86.8 ± 17.6[b]	107.6 ± 0.0[c]
Athletes	76.5 ± 5.5[a]	77.5 ± 12.1[a]	110.8 ± 16.1[b]
TSF(mm)			
Non-athletes	9.2 ± 3.1[a]	11.4 ± 4.5[b]	16.5 ± 0.0[b]
Athletes	6.5 ± 2.1[a]	8.1 ± 3.5[a]	19.1 ± 10.8[b]
Metric index			
Non-athletes	−1.25 ± 0.46[a]	−0.13 ± 0.24[b]	0.26 ± 0.00[b]
Athletes	−0.8 ± 0.0[a]	−0.36 ± 0.24[a]	0.70 ± 0.57[b]
Chest depth(cm)			
Non-athletes	17.4 ± 2.0[a]	22.6 ± 1.0[b]	23.8 ± 0.0[b]
Athletes	19.7 ± 1.5[a]	20.6 ± 2.3[a]	24.8 ± 1.7[b]
Chest breadth(cm)			
Non-athletes	27.2 ± 2.0[a]	31.9 ± 1.4[b]	34.9 ± 0.0[b]
Athletes	31.2 ± 3.6[ab]	29.6 ± 3.0[a]	33.9 ± 2.1[b]

With a given row, values with different superscripts are significantly different, $p < 0.05$

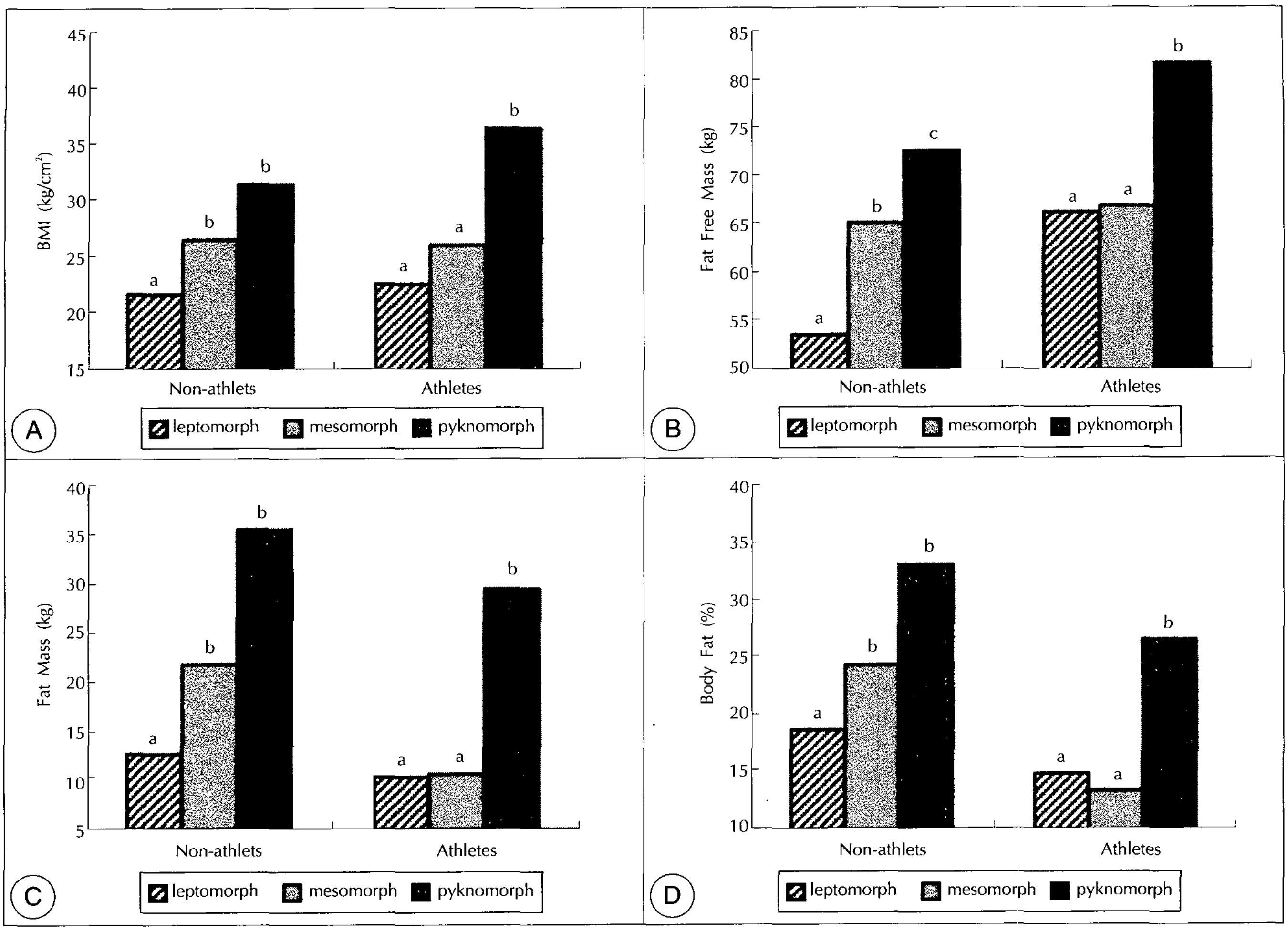

Fig. 1. Comparison of anthropometric variables in different body builds of non-atheletes and atheletes. A : Body mass index (kg/m_2), B : Fat-free mass (kg), C : Fat mass (kg), D : Body fat mass (%). Different alphabets indicates significant difference ($p < 0.05$).

in all the subgroups were in normal range. Such pattern of metabolic parameters in dependence on the body build of non-athletes is same as that of insulin than of body fat mass. Insulin stimulate lipogenesis and inhibit lipolysis in adipose tissue, and stimulate consumption of glucose in the various tissues. Therefore, the release of free fatty acid from the adipose tissue would be lower in mesomorph. The highest free fatty acid level in mesomorphic non-athletes seems to be caused by a decreased uptake into tissues and a greater oxidation rate. Also, the high serum lactate content in mesomorphic non-athletes, reflecting high glycolysis rate in tissues like muscle, could be attribute to the stimulating effects of insulin on glucose oxidation. The above change of energy substrate and metabolite would indicate that carbohydrate was for energy supply in the fasting state more preferentially consumed than fat in mesomorph than other body builds.

A different influence of body builds on carbohydrate metabolic status was found between non-athletic and athletic groups. Glucose concentration of athletes decreased slightly from leptomorphs to pyknomorphs, showing an opposite pattern to that of non-athletes, although the difference in glucose content among different body builds was not significant. It could be attributed to the relatively high insulin concentration in mesomorphs and pyknomorph. Lactate concentration was, although not significant, also slightly higher in mesomorph and pyknomorphs than leptomorphs, reflecting a high rate of glycolysis in both build types. As the pattern according to body builds corresponded to that of insulin concentration, high insulin content seems to cause higher anaerobic oxidation rates than other energy oxidative pathways in the same way as like its effects on the fasting glucose level.

Serum triglyceride and free fatty acid content of athletes did not show any significant difference in dependence on body build type. The leptomorphs and mesomorphs showed very low fasting levels of triglyceride, probably as a result of low fat mass in the body from physical train-

Table 7. Comparison of fasting serum glucose, triglyceride, free fatty acid, lactate and insulin concentration among different body builds of athletes and non-athletes (Mean ± SD)

Variables	Body builds		
	Leptomorph	Mesomorph	Pyknomorph
Glucose(mg/dl)			
Non-athletes	83.9 ± 14.0[a]	88.3 ± 18.2[a]	110 ± 0.0[a]
Athletes	106.5 ± 12.0[a]	100.3 ± 13.3[a]	85.0 ± 22.7[a]
Triglyceride (mg/dl)			
Non-athletes	82.2 ± 30.1[a]	127.3 ± 82.1[b]	92.0 ± 0.0[ab]
Athletes	54.0 ± 5.6[a]	92.5 ± 60.4[a]	121.0 ± 42.5[a]
Free fatty acid(μEq/l)			
Non-athletes	444.2 ± 267.0[a]	548.8 ± 222.5[a]	465.0 ± 0.0[a]
Athletes	318.0 ± 158.4[a]	310.2 ± 201.4[a]	346.5 ± 117.5[a]
Lactate(mMol/l)			
Non-athletes	2.97 ± 0.49[a]	4.80 ± 3.24[b]	2.90 ± 0.0[ab]
Athletes	1.75 ± 0.49[a]	2.28 ± 0.66[a]	2.08 ± 0.65[a]
Insulin(μU/ml)			
Non-athletes	9.12 ± 3.95[a]	21.3 ± 18.7[b]	20.7 ± 0.0[ab]
Athletes	5.15 ± 1.34[a]	10.9 ± 12.9[a]	10.3 ± 7.0[a]

Different superscripts in the same row indicates significant differences ($p < 0.05$) between groups by LSD (least squares difference) comparison test

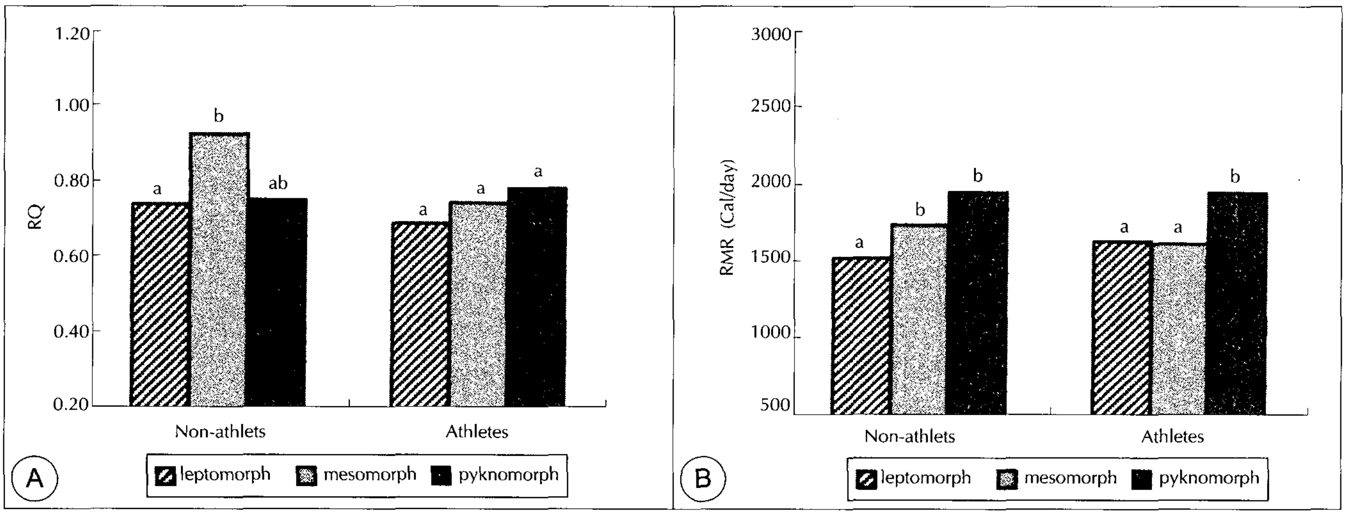

Fig. 2. Comparison of anthropometric variables in different body builds of non-atheletes and atheletes. A : Respiratory quotient, B : Resting metabolic rate (Cal/day). Different alphabets indicates significant difference ($p < 0.05$).

ing. Higher fatty acid concentrations were shown in pyknomorph possessing excessive fat mass than in other body builds. Furthermore, fasting insulin concentration is higher in this build type. As in non-athletes, the high level of free fatty acids in pyknomorph would, therefore, result from excessive reduction of free fatty acid oxidation rather than by its release from adipose tissue by the stimulation of insulin.

RMR and RQ in different body builds are shown in Fig. 2. Resting metabolic rate of non-athletes increased from leptomorphic to pyknomorphic type, as a result of high body weight and fat-free mass. In athletes, the RMR was shown to be significantly higher in pyknomorphic type than in leptomorphic type. This seems to reflect the larger fat-free mass and body weight in pyknomorphic type than in other body builds.

Mean of RQ in non-athletes was higher in mesomorphs than in other body builds. Considering the lactate and free fatty acid pattern, it is supposed to be not only an increase of whole carbohydrate oxidation rate, but also a higher rate glycolysis than of fat oxidation. This pattern of RQ in dependence on the body build agrees with that of serum insulin. Therefore, this would be due to the high insulin concentration. In athletes, pyknomorph have, although not significant, higher RQ than the leptomorphs, reflecting an increased carbohydrate oxidation and reduced fat oxidation proportion in pyknormorph. This pattern agrees also with that of body fat%, triglyceride, and free fatty acid content being opposite to that of serum glucose. The anaerobic carbohydrate oxidation, glycolysis rate did not show any difference between mesomorph and pyknomorph in athletes as like insulin.

As previously mentioned, the fat mass and fat percentage in pyknomorphic athletes increased. Also, it was shown in other study, that people with high fat mass or BMI have in general higher RQ value as compared to one with ideal body weight as a result of low proportion of fat oxidation,[36] As shown in the pattern of RQ, The pyknormorphic athletes would have rather lower lipolytic efficiency than other body builds, for which high efficiency is essential for endurance exercise. The mesomorphic athletes, having the higher insulin level without excess fat mass, showed lower RQ than pyknormorph. Considering this, the highest oxidation proportion of carbohydrate as energy source of pyknomorph in athletes was probably due to synergic effects of the body fat excess and increased insulin level. The high RQ, indicating relatively low lipolysis agreed to the increase of lactate, triglyceride and free fatty acid concentrations. In non-athletes, not the body fat excess, but the higher concentration of insulin in mesomorph seemed to cause not only the increase of anaerobic but also aerobic proportion of carbohydrate oxidation than fat, resulting in the high free fatty acid and lactate content.

From that above mentioned, it was shown that body build influence not only body composition, but also insulin which is the chief hormone regulating energy metabolism. As a result, body build type influence carbohydrate and fat metabolic state in blood, carbohydrate and fat oxidation proportion of body in a interrelated way. This study is the first one to investigate effects of body build on energy metabolic indicator using easily measurable bony anthropometry.

CONCLUSION

In this study, the relation of body build and metabolic state variables such as body composition, carbohydrate, and fat metabolism indicators in blood, resting metabolic rate, and RQ was investigated in non-athletes and athletes, using Metric index as a criterion of body build.

Most athletes have mesomorphic body build, in contrast to non-athletic students who have leptomorphic body build. The fat-free mass, fat mass, and fat percentage in non-athletes were increased from leptomorph to pyknomorphs. In the athletic group, only pyknomorphs have higher anthropometric values than other body build types.

Higher concentration of lactate, triglyceride, and free fatty acids in serum were observed in mesomorphic non-athletes. In athletes, no significant difference of such energy substrate and metabolite according to the body builds was observed. However, fasting glucose concentration in serum showed a decreasing tendency in pyknomorph. Lactate, triglyceride, and free fatty acids concentrations showed, in contrast, an increasing tendency in this build, and, as a result agreed to the pattern of serum insulin.

RMR in different body builds increased significantly from leptomorph to pyknormorph in non-athletes and athletes, as a result of change of body mass and fat-free mass in dependence or the body build types. RQ of fasting state were highest in mesomorphic non-athletes and in pyknormorphic athletes, indicating an increased use of carbohydrate rather than fat as chief energy source. The high RQ of athletic pyknormorph indicate, that in state of no dietary energy supply, lipolytic efficiency would be lower in pyknomorphs than in other body builds, and despite excessive fat reserves, energy supply from body fat would be restricted. Such effects may influence the performance of endurance sportler.

From the results of this study, it can be concluded that body build type is associated, not only with body composition, but also with insulin concentration, thus influencing carbohydrate and fat metabolism of both athletes and non-athletes. As a result, a change of energy oxidation ratio between carbohydrate and fat would occur. Therefore, the variation in body builds of individuals should be considered in investigation on the relationship between nutritional state and disease or exercise.

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