Chapter III

Methodology

In this chapter, the procedure adopted for selection of subjects, selection of variables, criterion measures, administration of the anthropometric variables, motor fitness variables, BMI and bone mineral density tests and the statistical technique used for the analysis of data are described.

Sample size of the study

The present study was performed on 25 volleyball players, 25 throwers, 25 bodybuilders and 25 swimmers healthy sportmen. \((n=100)\)

Selection of subjects

The subjects for the present study were:

1. Healthy sportmen from Iran only,
2. Aged between 18 to 28 years,
3. At least 5 years playing experiences in their fields,
4. Participated regularly at least 3 times in training sessions per week,
5. Participated at the highest national league matches for their age category (in except bodybuilding),
6. Informed about the procedures of the measurements including the risks and benefits,
7. They were free of any disease related to bone such as diabetes, hyperthyroidism, hyperparathyroidism, cardiovascular disease
8. They weren't taking any drugs viz cortone consumption, growth hormones or anabolic steroidal hormones, anti-seizure drugs, smoking cigarette and alcohol.

9. A standardized questionnaire assessing information regarding the personal and family history about bone fractures, exercise training and nutrition history was applied to remove risk factors that might interfere with bone metabolism.

10. Provided their written permission for participating in relation to the research policy.

Selection of variables for the study

After a comprehensive review of literature related to the BMD in books, journals, periodicals and research articles besides detailed discussion with the experts and keeping in view of the possibility of the study in terms of variability of instruments and the relevance of the variables to the present study, the following variables were selected.

Independent variables

The anthropometric variables, motor fitness variables and BMI of the selected subjects were the independent variable.

Dependent variable

The bone mineral density of the selected subjects was the dependent variable.
Methodology

Criterion Measures: Anthropometric Variables

Table 3.1: Anthropometric variables, tests, equipments and criterion measures

<table>
<thead>
<tr>
<th>Variables</th>
<th>Equipments</th>
<th>Criterion Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Body Mass (Weight)</td>
<td>Weighing Machine</td>
<td>kg</td>
</tr>
<tr>
<td>2. Stretch Stature (Height)</td>
<td>Stadiometer</td>
<td>cm</td>
</tr>
<tr>
<td>3. Sitting Height</td>
<td>Stadiometer</td>
<td>cm</td>
</tr>
<tr>
<td>4. Arm Span</td>
<td>Anthropometric Tape</td>
<td>cm</td>
</tr>
<tr>
<td>5. Arm Length</td>
<td>Segmometer</td>
<td>cm</td>
</tr>
<tr>
<td>6. Forearm Length</td>
<td>Segmometer</td>
<td>cm</td>
</tr>
<tr>
<td>7. Hand Length</td>
<td>Segmometer</td>
<td>cm</td>
</tr>
<tr>
<td>8. Thigh Length</td>
<td>Segmometer</td>
<td>cm</td>
</tr>
<tr>
<td>9. Tibial Length</td>
<td>Segmometer</td>
<td>cm</td>
</tr>
<tr>
<td>10. Humerus Breadth</td>
<td>Bone Caliper</td>
<td>cm</td>
</tr>
<tr>
<td>11. Wrist Breadth</td>
<td>Bone Caliper</td>
<td>cm</td>
</tr>
<tr>
<td>12. Femur Breadth</td>
<td>Bone Caliper</td>
<td>cm</td>
</tr>
</tbody>
</table>

Criterion Measures: Motor fitness variables

Table 3.2: Motor fitness variables, tests, equipments and criterion measures

<table>
<thead>
<tr>
<th>Variables</th>
<th>Test</th>
<th>Equipments</th>
<th>Criterion Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed</td>
<td>35 m speed test</td>
<td>Stopwatch</td>
<td>sec</td>
</tr>
<tr>
<td>Power</td>
<td>standing long jump</td>
<td>Tape measure</td>
<td>cm</td>
</tr>
<tr>
<td></td>
<td>vertical jump</td>
<td>Sargent board &amp; Chalk</td>
<td></td>
</tr>
<tr>
<td>Strength</td>
<td>1 RM test (Arm press &amp; Squat)</td>
<td>Free weights or machine</td>
<td>kg</td>
</tr>
<tr>
<td>Aerobic Endurance</td>
<td>Harvard step test</td>
<td>Step 20 inches &amp; Stopwatch</td>
<td>ml/(kg·min)</td>
</tr>
</tbody>
</table>
Criterion Measures: Body Mass Index (BMI)

Table 3.3: BMI, equipments and criterion measure

<table>
<thead>
<tr>
<th>Variables</th>
<th>Equipments</th>
<th>Criterion Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMI</td>
<td>Weighing machine and Stadiometer</td>
<td>kg/m²</td>
</tr>
</tbody>
</table>

Criterion Measures: Bone Mineral Density

Table 3.4: Bone Mineral Density, equipments and criterion measure

<table>
<thead>
<tr>
<th>Variables</th>
<th>Equipments</th>
<th>Criterion Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bone Mineral Density</td>
<td>DXA Machine</td>
<td>g/cm²</td>
</tr>
</tbody>
</table>

Collection of Data

The selected anthropometric variables, motor fitness variables, BMI and bone mineral densities were measured as per the procedure and instructions available in the literature. All the data were in numerical form.

Procedure for collecting of data

The study was carried out according to the moral principles for clinical research involving human subjects in accordance with the Declaration of Helsinki and all data were collected in the forenoon (8 to 12 am) in a clinic, gym and laboratory. First, the researcher assessed anthropometric variables, motor fitness variables and BMI in the clinic and gym. Later bone mineral densities were assessed in the laboratory.

Procedure for administration of tests

- **Anthropometric Assessment**

  All anthropometrical parameters were measured according to the protocol recommended by the International Society for the Advancement of Kinanthropometry
(ISAK). Anthropometric variables were measured after a light breakfast and without exercise for 12 hours. Those were conducted in the Health and Sport Clinic in the Faculty of physical Education & Sports Sciences in Islamic Azad University Aliabad Katool Branch, Iran.

**Weight (Body mass):**

**Objective:**

To measure of the body mass (weight)

**Equipment:**

Weighing machine

**Procedure:**

Perfectly, body weight should be obtained on an accurately type balance. The subject should be weighed with minimal clothes and 12 hours after eating food and after voiding in the morning (Marfell-Jones, 1991). The subjects were to stand still without support, with their weight evenly distributed over the centre of the scale, looking straight ahead, whilst the weight was recorded. Weight was recorded to the nearest 0.1Kg (See Figure 3.1).

![Figure 3.1: Measurement of Body Mass (Weight)](image-url)
**Methodology**

**Height (Stretch stature):**

**Objective:**

To measure of the maximum standing body height

**Equipment:**

Retractable metal tape stadiometer

**Procedure:**

The measurement was taken as the maximum vertical distance from the floor to the vertex (highest point on the skull) of the head. This position is achieved when the line joining the orbitale (the most inferior position on the margin of the eye socket) to the tragion (the notch above or superior to the flap of the ear) is horizontal or at right angles to the long axis of the body. This position corresponds almost exactly to the visual axis when the subject is looking directly ahead. In time of measurement, the barefoot subject stand erect with heels together, both heels touching the base of the stadiometer, and arms hanging naturally by the sides. The heels, buttocks, upper part of the back and usually the back of the head are in contact with the vertical wall. The subject “looks straight ahead” and “takes a deep breath”. One of the measurers ensures that the subject’s heels are not elevated while the other measurer applies stretch force, by cupping the subject’s head and applying firm traction alongside the mastoid processes. The first measurer then brings the headpiece firmly down crushing the hair and making firm contact with the vertex and makes a pencil mark on the paper tape level with the underside of the headpiece. Measurement is made before the subject exhales (Marfell-Jones, 1991). The measurement was read to the nearest 0.1 cm (See figure 3.2).
Figure 3.2: Measurement of Stretch standing stature (Height)
Sitting Height:

Objective:

To measure of the sitting height

Equipment:

Stadiometer

Procedure:

This measurement is usually made when the subject is seated on the box with the feet on the floor. Care must be taken to ensure that the subject does not push with the legs. An assistant orients the subject’s head in the Frankfort plane, instructs him or her to take a breath and sit as tall as possible, and applies gentle traction to the mandible and the base of the skull. The anthropometrist positions the anthropometer on the sitting base and brings the branch down, crushing the hair and making firm contact with the vertex. See Figure 3.3 (Marfell-Jones, 1991). The measurement was read to the nearest 0.1 cm (See figure 3.3).

Figure 3.3: Measurement of Sitting Height
Arm Span:

Objective:

To measure of the Arm span

Equipment:

Anthropometric tape

Procedure:

The subject faces a wall (head turned to one side) and places one dactylion against an edge or side wall. This dactylion is held in position by an assistant. The other dactylion is volitionally stretched along the wall for maximal span which is identified and then measured to the nearest 0.1 cm. The measurement can be made by anthropometric tape or against a calibrated wall chart with marked distances. See Figure 3.4 (Marfell-Jones, 1991).

Figure 3.4: Measurement of Arm Span
Arm length (Acromiale - radiale):

Objective:

To measure of the Arm length (Acromiale - radiale)

Equipment:

Segmometer

Procedure:

The subject stood erect with the arms at the sides, palms against the thighs. The length of the arm from acromion (outer edge of the shoulder blade) point of shoulder's joint to radius (upper and lateral border of the head of radius) was recorded with using a Segmometer. The measurement was read to the nearest 0.1 cm. See Figure 3.5 (Marfell-Jones, 1991).

Figure 3.5: Measurement of Arm length (Acromiale – radiale)
Objective:

To measure of the Forearm length (Radiale - stylion)

Equipment:

Segmometer

Procedure:

The elbow was flexed and the orientation of the tape was such that it parallels the long axis of the radius. The length of the forearm from radius (upper and lateral border of the head of radius) to styloid process (the lateral surface of the distal radius bone) was recorded with using a Segmometer. The measurement was read to the nearest 0.1 cm. See Figure 3.6 (Marfell-Jones, 1991).

Figure 3.6: Measurement of Forearm length (Radiale-sty lion)
Methodology

Hand length (midstylion - dactyliion)

Objective:

To measure of the Hand length (midstylion - dactyliion)

Equipment:

Segmometer

Procedure:

The subject extends the right hand supinated, fully extending the fingers. The length of the hand from mid-stylion (the distal wrist crease) to the dactyliion (the tip of the middle finger) was recorded with using segmometer. The measurement was read to the nearest 0.1 cm. See Figure 3.7 (Marfell-Jones, 1991).

Figure 3.7: Measurement of Hand length (Midystlion – dactylion)
Thigh length (Trochanterion - tibiale laterale)

Objective:

To measure of the Thigh length (Trochanterion-tibiale laterale)

Equipment:

Segmometer

Procedure

The subject stands with feet together on the box with the right leg facing the anthropometrist then the distance from the trochanterion (the most superior point on the greater trochanter of the femur) to the tibiale laterale (the most proximal point of the margo glenoidalis of the lateral border of the head of the tibia) was measured to the nearest 0.1 cm by using Segmometer. See Figure 3.8 (Marfell-Jones, 1991).

Figure 3.8: Measurement of Thigh length (Trochanterion - tibiale laterale)
Tibial length (Tibiale mediale - sphyrion tibiale)

Objective:

To measure of the Leg length

Equipment:

Stadiometer

Procedure:

The subject sits on the box and crosses the right ankle over the left knee to present the medial surface of the right leg horizontally. The distance from the tibiale mediale (the most proximal point of the margo glenoidalis of the medial border of the head of the tibia) to sphyrion tibiale (the most distal tip of the malleolare medialis (tibialis) was measured to the nearest 0.1 cm by using Segmometer. See Figure 3.9 (Marfell-Jones, 1991).

Figure 3.9: Measurement of Tibial length (Tibiale mediale - sphyrion tibiale)
Humerus Breadth (Bi-Epicondylar)

Objective:

To measure of the Humerus breadth (bi-epicondylar)

Equipment:

Bone caliper

Procedure:

The subject's arm is raised forward to the horizontal and the forearm is flexed to a right angle at the elbow. The distance between medial and lateral epicondyles of the humerus was measured by using the small bone caliper. The measurement was read to the nearest 0.1 cm. See Figure 3.10 (Marfell-Jones, 1991).

Figure 3.10: Measurement of Humerus breadth (Bi-epicondylar)
Methodology

Wrist Breadth (Bi-Styloid)

Objective:

To measure of the Wrist breadth (bi-styloid)

Equipment:

Bone caliper

Procedure:

The subject’s right forearm is resting on a table or the subject’s thigh and the wrist is flexed to an angle of about 90°. The distance between medial and lateral parts of wrist (bi-styloid) was measured by using the small bone caliper. The measurement was read to the nearest 0.1 cm. See Figure 3.11 (Marfell-Jones, 1991).

Figure 3.11: Measurement of Wrist breadth (Bi-styloid)
**Methodology**

---

**Femur Breadth (Bi-Epicondylar)**

**Objective:**

To measure of the Femur breadth (Bi-epicondylar)

**Equipment:**

Bone caliper

**Procedure:**

The subject is seated and the leg is flexed at the knee to form a right angle with the thigh. The distance between medial and lateral epicondyles (Bi-epicondylar) of the femur was measured by using the small bone caliper. The measurement was read to the nearest 0.1 cm. See Figure 3.12 (Marfell-Jones, 1991).

![Figure 3.12: Measurement of Femur breadth (Bi-epicondylar)](image)

---

71
Motor Fitness Assessment

Motor fitness tests were measured after 10 to 15 minutes warm up.

Speed

Objective:

To determine acceleration, maximum running speed in 35 meters

Equipment:

Measuring tape or marked track, stopwatch or timing gates, cone markers

Procedure:

The subject is started from a stationary position with a foot behind the starting line, with no rocking movements, and run with maximum speed toward finishing line. It is usual to give the athletes a practice first and some encouragement to continue running hard past the finishing line. The time of run was recorded by using stopwatch or timing gates to the nearest 0.01 second. Two attempts were allowed. See Figure 3.13 (Johnson & Nelson, 1969).

Figure 3.13: Speed test
Standing long jump

Objective:

To measure the explosive power of the legs

Equipment:

Tape measure to measure distance jumped, non-slip floor for takeoff, and soft landing area preferred. Commercial Long Jump Landing Mats are also available. The take off line should be clearly marked.

Procedure:

The athlete stands behind a line marked on the ground with feet slightly apart. A two feet take-off and landing is used, with swinging of the arms and bending of the knees to provide forward drive. The subject attempts to jump as far as possible, landing on both feet without falling backwards. Three attempts are allowed and the measurement is read to the nearest 0.1 cm. See Figure 3.14 (Johnson & Nelson, 1969).

Figure 3.14: Standing long jump
Methodology

Vertical jump

Objective:

To measure the explosive power of the legs

Equipment:

Measuring tape or marked wall, chalk for marking wall (jump mat).

Procedure

The athlete stands side on to a wall and reaches up with the hand closest to the wall. Keeping the feet flat on the ground, the point of the fingertips is marked or recorded. This is called the standing reach height. The athlete then stands away from the wall, and leaps vertically as high as possible using both arms and legs to assist in projecting the body upwards. The jumping technique can or cannot use a countermovement (see vertical jump technique). Attempt to touch the wall at the highest point of the jump. The difference in distance between the standing reach height and the jump height is the score. The best of three attempts is recorded. See Figure 3.15 (Johnson & Nelson, 1969).

Figure 3.15: Vertical jump (Sargent Test)
Strength (Squat and Head Press 1 RM) Tests

**Objective:**

To measure maximum strength of various muscle and muscle groups.

**Equipment:**

Free weights (barbells, dumbbells) or other gym equipment

**Procedure:**

One repetition maximum test (1RM) is a popular method of measuring isotonic muscle strength. It is a measure of the maximal weight a subject can lift with one repetition. It is important to reach the maximum weight without prior fatiguing the muscles. After a warm up, choose a weight that is achievable. Then after a rest of at least several minutes, increase the weight and try again. The athletes chooses subsequent weights until they can only repeat one full and correct lift of that weight (See Figure 3.16). The maximum weight lifted is recorded. The sequence of lifts should also be recorded as these can be used in subsequent tests to help in determining the lifts to attempt (Johnson & Nelson, 1969).

![Figure 3.16: Head press (Left) and Squat (Right) 1 RM tests](image)
Aerobic Endurance (Harvard step test)

Objective:
To measure aerobic fitness and capacity

Equipment:
Platform 20 inches high, stopwatch and metronome

Procedure:
The athlete steps up and down on the platform at a rate of 30 steps per minute (every two seconds) for 5 minutes or until exhaustion. Exhaustion is defined as when the athlete cannot maintain the stepping rate for 15 seconds. The athlete immediately sits down on completion of the test, and the total number of heart beats is counted between 1 to 1.5 minutes after finishing (see measuring heart rate). This is the only measure required if using the short form of the test. If the long form of the test is being conducted, there is an additional heart rate measures at between 2 to 2.5 minutes, and between 3 to 3.5 minutes. See some videos of Harvard Step tests being performed.

Scoring: the Fitness Index score is determined by the following equations. For example, if the total test time was 300 seconds (if completed the whole 5 minutes), and the number of heart beats between 1-1.5 minutes was 90, between 2-2.5 it was 80 and between 3-3.5 it was 70, then the long form Fitness Index score would be: \((100 \times 300)/(240 \times 2) = 62.5\). Note: you are using the total number of heart beats in the 30 second period, not the rate (beats per minute) during that time (Johnson & Nelson, 1969).
**Methodology**

- **Body Mass Index (BMI)**

**Objective:**

To measure of the body mass index

**Equipment:**

Scales and stadiometer as for weight and height

**Procedure:**

BMI is calculated from body mass \(M\) and height \(H\). 

\[
BMI = \frac{M}{H \cdot H},
\]

where \(M\) = body mass in kilograms and \(H\) = height in meters. The higher score usually indicate higher levels of body fat.

- **Bone Mineral Density (BMD)**

**Objective:**

To measure of the bone mineral density

**Equipment:**

DXA (Dual-energy X-ray absorptiometry)

**Procedure:**

Bone density tests are a quick and painless procedure. The person lays on the whole body scanner, with the x-ray sources mounted beneath a table and a detector overhead. The person is scanned with photons that are generated by two low-dose x-rays at different energy levels. The body's absorption of the photons at the two levels is measured. The ratios can be then used to predict total body fat, fat-free mass and total body bone mineral. The procedure can take about 10 - 20 minutes. And on the day of the exam the person may eat normally, should not take calcium supplements for at least 24 hours before the test.
To evaluate the spine, the patient's legs are supported on a padded box to flatten the pelvis and lower (lumbar) spine. To assess the hip, the patient's foot is placed in a brace that rotates the hip inward- “pigeon-toed” position to rotate the hips and give the largest projected area to measure. For the arm and wrist measurement, the person sits on a chair beside the machine and places an arm into a holding device while the measurement is taken. In all cases, the detector is gradually passed over the area, generating images on a computer monitor. The person must hold very still and may be asked to keep from breathing for a few seconds while the x-ray picture is taken to decrease the risk of a blurred image. The person should wear free, comfy clothing, avoiding garments that have zippers, belts or buttons made of metal. Objects such as keys or wallets, etc, that would be in the area being scanned should be removed that might interfere with the x-ray images. See figure 3.17.

![Dual-energy X-ray Absorptiometry](image)

**Figure 3.17: Dual-energy X-ray Absorptiometry**
Statistical Techniques used for Analyses of Data

After collecting the data the below mentioned statistical techniques were used to analyze and to interpret the study.

- **Statistical Techniques**

  Descriptive statistics was used for anthropometric variables, motor fitness variables, BMI and bone mineral densities data.

  Stepwise multiple Regression analysis was carried out for anthropometric variables, motor fitness variables and BMI to predict bone mineral density at lumbar bones (L2-L4), neck of the femur and wrist.

  All statistical analyses are carried out with the SPSS (version 14) statistical package (SPSS Inc., Chicago, IL).