METHODS AND APPARATUS FOR MUSCLE SPECIFIC RESISTANCE TRAINING

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Abstract
Disclosed is a muscle specific exercise device. The device may provide passive or active resistance training throughout an angular range of motion. The device may be low profile, and worn by a wearer, such as beneath conventional clothing. Exercise of selective joints or motion of the body may thereby be accomplished throughout the wearer’s normal daily activities, without the need for access to conventional exercise equipment. Alternatively, the device may be worn as a supplemental training tool during conventional training techniques.
FIG. 6
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CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Application No. 61/218,607, filed Jun. 19, 2009, the entirety of this application is hereby incorporated by reference herein.

BACKGROUND OF THE INVENTION

[0002] Resistance training, sometimes known as weight training or strength training, is a specialized method of conditioning designed to increase muscle strength, muscle endurance, and muscle power. Resistance training refers to the use of any one or a combination of training methods which may include resistance machines, dumbbells, barbells, body weight, and rubber tubing.

[0003] The goal of resistance training, according to the American Sports Medicine Institute (ASMI), is to “gradually and progressively overload the musculoskeletal system so it gets stronger.” This is accomplished by exerting effort against a specific opposing force generated by elastic resistance (i.e., resistance to being stretched or bent). Exercises are isometric if a body part is holding still against the force. Resistance exercise is used to develop the strength and size of skeletal muscles. Full range of motion is important in resistance training because muscle overload occurs only at the specific joint angles where the muscle is worked. Properly performed, resistance training can provide significant functional benefits and improvement in overall health and well-being.

[0004] Research shows that regular resistance training will strengthen and tone muscles and increase bone mass. Resistance training should not be confused with weightlifting, power lifting or bodybuilding, which are competitive sports involving different types of strength training with non-elastic forces such as gravity (weight training or plyometrics) an immovable resistance (isometrics, usually the body’s own muscles or a structural feature such as a door frame).

[0005] Resistance exercise equipment has therefore developed into a popular tool used for conditioning, strength training, muscle building, and weight loss. Various types of resistance exercise equipment are known, such as free weights, exercise machines, and resistance exercise bands or tubing. Various limitations exist with the prior art exercise devices. For example, many types of exercise equipment, such as free weights and most exercise machines, are not portable. With respect to exercise bands and tubing, they may need to be attached to a stationary object, such as a closed door or a heavy piece of furniture, and require sufficient space. This becomes a problem when, for example, the user wishes to perform resistance exercises in a location where such stationary objects or sufficient space are not readily found. Resistance bands are also limited to a single resistance profile in which the amount of resistance changes as a function of angular displacement of the joint under load.

[0006] A need therefore exists for resistance exercise equipment that is portable, that may be used on its own without the need to employ other types of equipment, and that allows for adjustable resistance modes and levels.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] FIG. 1 is an anterior lateral schematic view of an exercise assembly in accordance with the present invention, configured for positioning about the knee.

[0008] FIG. 2 is a plot of different resistance profiles as a function of angular rotation of a joint, which may be accomplished by the exercise assemblies of the present invention.

[0009] FIG. 3 is a schematic, exploded view of a resistance element in accordance with the present invention.

[0010] FIG. 4 is a perspective schematic view of an alternate resistance element in accordance with the present invention.

[0011] FIG. 5 is a lateral view of an exercise assembly in accordance with the present invention.

[0012] FIG. 6 is a posterior view of an alternate exercise assembly of the present invention.

[0013] FIGS. 7 and 8 are side and plan views of an exercise insert, which may be attached to an article of clothing or other support structure in accordance with the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0014] Detailed descriptions of the preferred embodiments are provided herein. It is to be understood, however, that the present invention may be embodied in various other forms. Therefore, specific details disclosed herein are not to be interpreted as limiting, but rather as a basis for the claims and as a representative basis for teaching one skilled in the art to employ the present invention in virtually any appropriately detailed system, structure or manner.

[0015] Referring now to FIG. 1 there is disclosed a perspective view of a quadriceps/hamstring version of an exercise apparatus in accordance with the present invention. FIGS. 1, 5 and 6 show an embodiment of an apparatus that is designed to exercise the quadriceps and hamstring muscles, however, as will be described below, other versions of exercise apparatus are contemplated for exercising other muscles, muscle pairs or groups such as biceps/triceps, thoraco-lumbar-abdominal, chest/back, latissimus dorsi/pectoralis and others that may benefit from a common bi-directional resistance muscle training system for multiple groups of muscles.

[0016] The knee joint is a uni-axial hinge joint. The knee moves in a flexion (bending of the knee) and extension (straightening of the knee) direction. The three major bones that form the knee joint are: the femur (thigh bone), the tibia (shin bone), and the patella (kneecap). The prime muscle movers of the knee joint are the quadriceps muscles (on top of the femur), which move the knee into extension; and the hamstring muscles (underneath the femur), which move the knee into flexion. The quadriceps muscles are made up of five muscles known as the rectus femoris, vastus lateralis, vastus medialis, vastus intermedius and a secondary muscle, the vastus medialis oblique (VMO). The hamstring is made up of three muscles known as the biceps femoris, semimembranosus, and semitendinosus. The hamstring to quadriceps muscle strength ratio is two-thirds; meaning, the hamstring is normally approximately thirty-three percent weaker than the quadriceps. The muscles, ligaments, nervous system, and skeletal system work in unison to stabilize the knee during gait activities (walking, running, jumping).
In general, the devices in accordance with the present invention are designed to provide resistance to motion between a first region and a second region of the body such as across a simple or complex joint, throughout an angular range of motion. The resistance can be either unidirectional, to isolate a single muscle or muscle group, or bidirectional to exercise opposing muscles or muscle groups. Optimally, the device will be user adjustable to select uni or bidirectional resistance.

In the example of a knee brace, configured to train quadriceps, the device imposes resistance to extension of the lower leg at the knee joint and throughout the angular range of motion for the knee. During flexion (movement in the return direction) the device may be passive without providing any resistance to movement. Alternatively, in a bidirectional device, the device imposes resistance throughout both extension and flexion in this example to train both the quadriceps and the hamstring muscles. The resistance to flexion and extension may be equal, or may be dissimilar, depending upon the objective of the exercise.

The devices in accordance with the present invention may also be provided with a user adjustable load or resistance.

In one implementation of a unidirectional device, the device is biased in a first direction, to load movement in a second, opposite direction. Bias may be provided by any of a variety of springs, elastic bands or other structures which exert a force opposite to the direction of motion. At any point throughout the angular range of motion except a single end point, the user must exert force against the device, whether the subject joint is stationary or in motion. This is distinct from the passive device, which exerts no force in the absence of motion.

In an alternate implementation, the device provides passive resistance to motion. At rest, the device imposes no bias, but the device imposes a resistance to motion in either one or both directions.

In one mode of operation, the device is worn over an extended period of time wherein the activities of the wearer are dominantly aerobic as distinguished from anaerobic (i.e. dominantly non-anaerobic). The invention may be practiced where some of the activities are of an aerobic nature, but in order to optimize certain benefits from the invention a higher degree of aerobic activities would be done. The extended period of time could be as short as one hour or less but is preferably at least two hours and sometimes at least eight hours, although it could also be at least about four hours or six hours or more.

Aerobic activity means that all of the metabolic oxygen requirements of the active tissues of the body are being fully met by the oxygen supply transported in the blood at that time. Activity levels that stay within these requirements are classified as aerobic and last beyond 5-7 minutes of continuous, rhythmic exercise. The principal fuels are fat and sugar, and the predominant by-products are CO₂, H₂O, heat and large quantities of adenosine triphosphate (ATP).

Anaerobic activity means that the metabolic oxygen requirements of the active tissues of the body exceed the oxygen supply being transported in the blood at that time. Any aerobic activity can become an anaerobic activity if the intensity of the exercise becomes increasingly harder so that the oxygen requirement of the active body tissues begins to exceed the blood's oxygen supply. High intensity activities that can only be sustained for periods of time less than 5-7 minutes fit the anaerobic classification. The principal fuel for anaerobic activity is sugar, and the predominant byproduct is lactic acid.

Metabolically, people are never perfectly aerobic, or perfectly anaerobic. Instead, the body functions more dominantly in one condition than the other based on the intensity or the duration of the activity in which the body is engaged. Thus, even though the total distance is the same, a swimmer will provoke an entirely different metabolic response by swimming 10x100 yards hard on a 1:30 interval than by swimming an easy 1,000 yards straight.

During aerobic activity, the muscular demand for oxygen is always less than or equal to the supply of oxygen being delivered by the body's circulatory system. The subject is able to work comfortably for long periods of time without experiencing undue respiratory distress, muscular discomfort, or muscular failure. The primary fuel sources for maintaining this aerobic condition are fat (triglyceride) and sugar (carbohydrate/glucose/glycogen).

During resting conditions, the consumption ratio is roughly ¾ fat and ¼ carbohydrate with a trace of protein. Both provide the necessary ATP (potential high-energy molecule) that the muscles use for their contraction process. As long as the oxygen supply to the active tissue is equal to or greater than the metabolic requirement, glucose molecules are actively transported into the muscle via insulin while the free fatty acid (FFA) molecules freely cross the cell membranes. Sugar (glycogen) previously stored in the muscle cells is added to the potential fuel supply.

Once inside the cell, cellular enzymes dismantle the molecules into carbon, hydrogen, and oxygen. The oxygen and carbon combine to form CO₂, which is returned to the lungs via the blood stream for us to exhale. The remaining hydrogen ions are shuttled by active transporters called NAD and FAD into the small energy-producing organelles called mitochondria. The hydrogen and oxygen combine to form H₂O which we eliminate through sweating, breathing, our intestines and bladder. The heat produced during the enzyme activity maintains our body core temperature and elevates it during exercise. Large quantities of the high energy ATP are produced to sustain prolonged, continuous muscular activity.

As the intensity of muscular activity increases, the oxygen requirement increases; body core temperature elevates; the brain signals the adrenal medullas to secrete epinephrine (adrenaline); blood delivers the epinephrine throughout the body; the epinephrine stimulates the Beta receptors of fat cells (adipocytes) by triggering internal adipocyte lipase to dismantle the stored triglyceride into FFA's and glycerol. The muscles use the FFA's as previously described, and the liver catabolizes the glycerol and reduces it to H₂O and heat, both of which we eliminate.

Thus, extended easy to moderate training is a better way to burn fat, and, as discussed below, high intensity exercise is a better way to build burst strength. The elite athlete can not optimize their training regimen unless they know the crossover point. This can be evaluated, for example, by monitoring blood for the appearance of elevated lactic acid which signals the conversion to anaerobic activity. Both improve strength.

Aerobic activities include sleeping, sitting, and exercise activities that produce heart rates that are about 85% or less of one's estimated maximum rate. Roughly estimated, this is 170-160 bpm for healthy people 20-30 years old; 153-145 for healthy people 30-50 years old, and above age 50
it may be in the range of about 140-128. Above about 85%, the body's demand for oxygen beings to overtake the blood's oxygen supply, and a person begins the transition into anaerobic dominance. The change-over can be easily documented using laboratory metabolic analyzer systems, but this is not always practical. The simplest method is to monitor one's own breathing process during exercise. If it's easy to speak to someone while exercising, then one is dominantly aerobic. If one has to use a halting speech pattern due to the need for frequent breaths, then one is in transition. If getting a breath of air is more important than speaking, then one is dominantly anaerobic.

[0032] Activities that last less than about 10 seconds do not produce lactic acid, and they do not utilize glycogen (sugar stored in the muscle). ATP that has been previously produced by aerobic and anaerobic activity and has been stored in the muscle is used for such short-burst activities. Examples include blinking one's eye, twitching a finger, exploding out of starting blocks in a track event, sprinting 35 yds (i.e., football drills), or possibly up to a 25 yard sprint for an elite, in condition swimmer.

[0033] During the short burst activity ATP is split by an enzyme to release the potential energy in the compound. Within microseconds upward to about 30 seconds, ADP and the separated terminal phosphate are re-united by creatine phosphate to re-create another ATP molecule to be used again. The liberated energy is used for muscular contraction and resynthesis of ATP.

[0034] High intensity muscular activity exceeding about 10 seconds requires more oxygen than the blood can supply to the active muscle tissues. This hypoxic (insufficient oxygen) condition activates an enzyme in the muscle cell which interrupts the aerobic sugar and fat metabolism pathway. One molecule of stored muscle sugar (glycogen) and one molecule of the blood sugar (glucose) entering the cell are converted to two molecules of pyruvic acid. Pyruvic acid is reduced into lactic acid. Minimal amounts of ATP are produced.

[0035] This snowball effect quickly increases the lactic acid concentration, further increasing the anaerobic enzyme activity to produce more lactic acid. Lactic acid spilling over into the blood stream is circulated to fat cells and impairs the stimulation of fat cell lipase by the circulating adrenaline. Fat cell triglyceride is not released into the blood stream which deprives the muscle cells of a supply of fat for their aerobic use. The reduction in available fat cuts down the aerobic activity of the ATP-producing muscle mitochondria. Increasing the exercise intensity, depriving the muscle mitochondria of fat and oxygen, increasing the lactic acid concentration all stimulate the increased activity of the anaerobic enzyme activity. The process is a cycle that feeds itself until there is not enough ATP to continue driving the muscle. The result is muscle fatigue and failure.

[0036] Heart rates exceeding about 90% of one's estimated, age-adjusted maximum typically accompany anaerobic metabolism dominance.

[0037] Even during this type of high-intensity work, we are still not perfectly anaerobic. While muscles in one part of the body are working aerobically, others are working anaerobically. When the preponderance of muscle tissue is working anaerobically, the ratio of sugar and fat use switches to ¾ fat and ¼ sugar rather than the ½ fat and ½ carbohydrate consumed at lower exertion levels.

[0038] The present invention is intended primarily for use to build strength under conditions which favor aerobic metabolism, which, in view of the foregoing will as a necessary consequence be accompanied by an elevated consumption of body fat. Thus the present invention may also comprise methods of achieving weight loss, by wearing one or two or more passive resistance devices for an extended period of time (disclosed elsewhere herein) each day for at least two or three or four or five or more days per week. The present invention also contemplates methods of reducing percent body fat via the same method steps.

[0039] In one embodiment, there is provided a knee support assembly with an upper leg attachment and a lower leg attachment. The two attachments are coupled together by interior (medial) and exterior (lateral) joint assemblies. These joint assemblies may comprise simple, uniaxial pivots, bicentric pivots, or more complex mechanisms which seek to mimic true joint motion. Additionally, other embodiments of the joint support assembly include abutting features that limit the angular range of movement of the upper attachment relative to the lower attachment in flexion, extension, or both flexion and extension. The device may alternatively span the hip, with a waist band attachment such as a wide adjustable belt linked to a right and left leg attachment across a left and right flex zone which each imparts resistance to movement of the hip. A three attachment zone construct may be provided which includes a waist attachment, a first and second thigh attachment and a first and second calf attachment, to provide resistance to both hip and knee movement. This may take the form of an article of clothing such as a compression garment with stretch panels, stiffening slats or flex structures disclosed elsewhere herein carried by the compression garment.

[0040] Exercise devices in accordance with the present invention also include a force modifying apparatus that interconnects, in the knee example, the upper and lower leg attachments. This force modifying apparatus can be a damper mechanism which provides a force which opposes flexion of the joint, extension of the joint, or both flexion and extension. In some embodiments this opposing force is a function of the angular velocity of the upper leg attachment relative to the lower leg attachment. In yet other embodiments the opposing force is also, or alternatively, a function of the angular displacement of the upper leg attachment relative to the lower leg attachment. In still other embodiments the opposing force is also, or alternatively, a function of the history of the angular velocity and/or the angular position of the upper leg attachment relative to the lower leg attachment.

[0041] In some embodiments the force modifying apparatus is a fluid damper, such as a hydraulic or pneumatic damper. In one embodiment, the force modifying apparatus is a hydraulic shock absorber whose resistance is a function of direction, velocity, and manual adjustment setting. In some embodiments the fluid damper is a linear device, such as with a piston and rod that extend out from a cylinder. In yet other embodiments the fluid damper is of the rotary type. An example of a rotary damper can be found in U.S. Pat. No. 7,048,098 to Moradian, and also in U.S. Patent Application Publication No. 2006/0096818 A1 (to Moradian).

[0042] Yet other embodiments of the present invention include a joint support assembly which includes an electronic data logger. In some embodiments, this data logger records electrical signals which are related to the load being transmitted by the force modifying apparatus, the angular position of the upper leg attachment relative to the lower leg attachment,
and/or the angular velocity of the upper leg attachment relative to the lower leg attachment.

[0043] Various dimensions and materials are described herein. It is understood that such information is by example only, and is not limiting to the inventions.

[0044] FIG. 1 shows an anterolateral elevational view of a passive exercise assembly 20 for a human knee. However, the present invention is not limited to exercising human knees, and can be used with other joints, such as human elbow joints and elsewhere as described above. Further, the devices and methods described herein are not limited to humans, but can also be applied to limbs of other animals.

[0045] The passive exercise assembly 20 comprises an upper leg attachment 22, movably associated with a lower leg attachment 24. The upper leg attachment 22 comprises at least a first connector 26 for releasable connection above the knee, to the leg of a wearer. First connector 26 may comprise any of a variety of structures, such as a strap 28 having a releasable clip or buckle 30 as is understood in the art. Any of a variety of snaps, buckles, Velcro, or other connectors may be utilized. An additional connector 32 may be provided, depending upon the desired performance characteristics.

[0046] The first connector 26 may be carried by at least a first proximal strut 34 and preferably a second proximal strut 36, which extend between a proximal support 38 and a flex zone 40. The structural components of the exercise assembly 20, including the proximal support 38, first proximal strut 34 and second proximal strut 36 may be constructed from any of a variety of materials which provide sufficient rigidity for the intended purpose. For example, molded polymeric material such as high density polyethylene, nylon, PEEK, PEBA, and others may be utilized. Alternatively, lightweight metal, such as aluminum, magnesium or nickel-titanium alloys may be utilized, as well as composites including carbon fiber assemblies. Optimal embodiments of the present invention will include relatively high strength, low profile construction, such that the passive resistance exercise devices of the present invention may be worn comfortably beneath normal street clothing, without detection.

[0047] The lower leg attachment 24 may be approximately symmetrical about the flex zone 40 with the upper leg attachment 22, except that it will generally be smaller in scale due to the normal difference in size between the quadriceps and the calf. In general, lower leg attachment 24 will comprise a distal support 42 separated from flex zone 40 by a first distal strut 44 and, preferably, a second distal strut 46. At least a second connector 48 is provided, for releasable connection to the wearer’s leg, at a point below the knee. Second connector 48 may comprise a strap 50 with a releasable buckle 52 or other releasable connection device. As will be apparent to those of skill in the art, the foregoing structure is adapted for positioning the flex zone 40 in the vicinity of the wearer’s joint, in this instance a knee. The upper leg attachment 22 is adapted for connection about the quadriceps, and the lower leg attachment 24 is adapted for connection about the calf.

[0048] The flex zone 40 comprises at least a first dynamic joint 54, and, preferably, a second dynamic joint 56. The dynamic joints 54 and 56 will generally although not necessarily be symmetrical about the wearer’s joint, and only a single dynamic joint will be described in greater detail below. It will be understood, however, that the description of the single dynamic joint applies equally to both.

[0049] The dynamic joint 54 permits the exercise assembly 20 to pivot or flex about an axis or a zone, to allow normal angular movement of the knee or other joint or flexible aspect of anatomy to be exercised. In one embodiment, the first dynamic joint 54 and second dynamic joint 56 are each pivotable about an axis which extends transversely to the longitudinal axis of the straightened leg. However, as described elsewhere herein, true anatomical movement of the leg throughout its angular range of motion is more complex than a single pivot point motion, and the first dynamic joint 54 and second dynamic joint 56 may be more complex structures which permit shifting of the axis of rotation at various points throughout the angular range of motion.

[0050] The dynamic joint 54 includes at least one resistance element to impose resistance to angular movement of the lower leg attachment 24 with respect to the upper leg attachment 22. The resistance may be in both extension and flexion directions, or may be 0 in extension, above 0 in flexion, or 0 in flexion and above 0 upon extension. Alternatively, the dynamic joint 54 may impose resistance to motion in both the flexion and extension directions, however at a different level of resistance.

[0051] The angular range of motion permitted by the dynamic joint 54 may be within the range of from about 0° (straight leg) to about 145° or more. Typically, an angular range of motion between about 0° and about 45° or 55° is sufficient for a joint such as the knee.

[0052] In bi-directional exercise device, the first dynamic joint 54 preferably provides resistance to movement in both the flexion and extension directions. However, the level of resistance may differ. For example, in a normal knee, the ratio of the natural strength of a hamstring to a quadriceps is roughly 1:3. A balanced passive resistance device may therefore impose 1 lb. of resistance on flexion for every 3 lbs. of resistance on extension. However, for certain athletic competitions or other objectives, the wearer may desire to alter the basic strength ratio of the unexercised hamstrings to quadriceps. So for example, the passive exercise device 20 may be provided with a 2 lb. resistance on flexion for every 3 lb. resistance on extension or other ratio as may be desired depending upon the intended result.

[0053] The resistance imposed upon either flexion, extension, or both may be preset by the manufacturer, or may be adjustable by the wearer. As will be discussed in greater detail below, adjustability may be accomplished by either adjustment of a single dynamic joint 54 such as throughout a continuous or stepped range, or by replacement of a component of the dynamic joint 54 by a replacement component having a different resistance characteristic.

[0054] The dynamic joint 54 may impart any of a variety of resistance profiles, as a function of angular displacement of the joint. For example, FIG. 2 schematically and qualitatively illustrates the pounds of resistance to movement in either or both an extension or flexion direction, as a function of the angular deviation of the joint across a dynamic motion range. In this illustration, an angle of zero may represent a limb in a “start” or straight configuration, while an angle of 90° may represent the limb flexed about the joint through an angle of 90°. The hypothetical joint plotted in FIG. 2 is flexible throughout an angular range of 145°.

[0055] Referring to plot 60, there is illustrated an example of the dynamic joint 54 in which the resistance to movement is constant throughout the angular range of motion, as a function of angle. Thus, at whatever point the distal extremity may be throughout the angular range of motion with respect
to the adjacent joint, incremental motion encounters the same resistance as it would at any other point throughout the angular range of motion.

[0056] Alternatively, referring to plot 62, there is illustrated the force curve relating to a dynamic joint 54 in which the resistance to motion is greatest at the beginning of deviation from linear, and the resistance to motion falls off to a minimum as the distal extremity reaches the limit of its angular range.

[0057] Referring to plot 64, the dynamic joint 54 imposes the least resistance at the beginning of bending the limb from linear, and the force opposing motion increases as a function of angular deviation throughout the range of motion. This may be utilized, for example, to emphasize building strength on the back half or back portion of an angular range of motion.

[0058] As a further alternative, referring to plot 66, the dynamic joint 54 may be configured to produce the most strength at the end points of the range of motion, while deemphasizing a central portion of the range of motion. Although not illustrated, the inverse of the plot 66 may additionally be provided, such that the end points in either direction of the angular range of motion across a joint are deemphasized, and strength throughout the middle portion of the range of motion is emphasized.

[0059] As will be apparent to those of skill in the art, any of a variety of resistance profiles may be readily constructed, depending upon the desired objective of the training for a particular athlete.

[0060] The resistance element 70 contained within each dynamic joint may comprise any of a variety of structures which are capable of imparting a constant or variable resistance throughout the angular range of motion. For example, one simple adjustable resistance joint is illustrated schematically in exploded view in FIG. 3.

[0061] Resistance element 70 comprises a first component 72 which is moveably connected to second component 74. In the illustrated embodiment, first component 72 comprises at least a first flange 78, preferably a second flange 80 and, as illustrated, a third flange 82 which extend generally parallel to each other and are spaced apart by spaces 84. The second component 74 is provided with at least one flange 86 and preferably a second flange 88. Flanges 86 and 88 are dimensioned such that they fit within the spaces 84. A transverse aperture may be provided, such that a pin 92 may be advanced therethrough to retain the first and second components 72 and 74 in pivotable relationship with each other. A control 190 may be provided, for either permanently fixing or adjustably providing a compression along the axis 76 to create resistance to relative rotation of the first component 72 with respect to the second component 74 about the axis 76. In a simple implementation of the invention, pin 72 may be provided with a threaded zone, and control 70 may be provided with a complementary thread, such that rotation of control 90 about pin 92 increases or decreases axial compression along the axis 76. The resistance element 70 may be integrated into the dynamic joint in manners that will be apparent to those of skill in the art.

[0062] Alternatively, referring to FIG. 4, a resistance element 100 may be provided in the form of a removable housing 100. Housing 100 may comprise a first engagement structure 102 which is moveable with respect to a second engagement structure 104 throughout an angular range 106. The interior of the housing 100 may be provided with any of a variety of mechanisms, such as complementary friction surfaces, coil springs, and simple or complex gear trains. The resistance element 100 may be configured to be removably received within a corresponding cavity in the dynamic joint 54. When the resistance element 100 is disposed within the cavity, the first engagement structure 102 engages a corresponding, complementary engagement structure connected to the upper leg attachment 22, and the second engagement structure 104 engages a corresponding complementary structure connected to the lower leg attachment 24. For example, one or both of the first engagement structure 102 and second engagement structure 104 may comprise a pin, tab, aperture, or other structure which may conveniently be removably interlocked within a complementary structure carried by the exercise assembly 20.

[0063] The foregoing configuration enables the athlete to select a resistance element 70 from an array of resistance elements having graduated or otherwise dissimilar resistance characteristics. A desired resistance element may then be easily dropped into a cavity or otherwise attached to the exercise assembly 20, to provide the desired performance. When it is desired to alter the performance of the exercise assembly 20, the first resistance element 70 may be removed and a second resistance element 70, having a different resistance characteristic may be mounted in or on the exercise assembly 20. Different resistant elements 70 may be color coded or otherwise marked with indicia of the resistance characteristic. The dynamic joint 54 may be provided with a housing, a cavity therein for receiving the resistance element 70, and optionally a cover, which may be snap-fit, or hingely closed once the resistance element 70 is mounted thereon, to retain the resistance element 70 in engagement with the exercise assembly 20.

[0064] Referring to FIGS. 5 and 6, there are illustrated lateral views and posterior views, respectively, of alternate configurations of the passive exercise device 20. In general, the passive exercise device in FIG. 5 is a bilateral resistance device having a first dynamic joint 54 and a second dynamic joint (not illustrated) as disclosed in FIG. 1. Any of the resistance elements disclosed elsewhere herein may be permanently or removably integrated into the dynamic joint 54. The upper leg attachment 22 and lower leg attachment 24 are illustrated in a slightly different configuration than those illustrated in FIG. 1.

[0065] Referring to FIG. 6, there is illustrated a unilateral resistance training device. Only a single dynamic joint 54 is provided. In this embodiment, the upper leg attachment 22 and lower leg attachment 24 are both configured for rapid mounting and dismounting from the leg or other joint of the wearer. As illustrated in FIG. 6, neither the upper leg attachment 22 nor lower leg attachment 24 is provided with a connector of the type which completely encircles the adjacent limb.

[0066] A simple passive resistance exercise device may be configured similar to that illustrated schematically in FIGS. 7 and 8. As illustrated therein, a passive exercise assembly 20 is provided with an upper leg attachment 22 and a lower leg attachment 24 which exhibit a minimal profile (thickness) so that the device 20 may be worn beneath clothing without detection. The upper leg attachment 22 comprises an elongate attachment strip 120, and the lower leg attachment 24 may comprise a lower elongate attachment strip 122. Attachment strip 120 may be provided with at least one aperture 124 for receiving a strap therethrough for surrounding the adjacent limb. A second aperture 126 and, optionally, a third aperture 128 may optionally be provided. The number of apertures and
the distance of the apertures from the flex zone 40 may be selected depending upon the relative resistance intended to be provided by the exercise assembly 20.

[0067] Similarly, the lower attachment strip 122 may be provided with at least one aperture 130 optionally a second aperture 132 and further optionally a third aperture 134 for receiving additional straps, for surrounding the adjacent limb.

[0068] The flex zone 40 may be provided with a dynamic joint having any of the characteristics described elsewhere herein. In the illustrated embodiment, a first and optionally second resistance element 140 and 142 are provided in frictional engagement with a friction surface 144. As illustrated, resistance element 140 and 142 are mechanically linked to the upper attachment strip 120, while resistance surface 144 is mechanically linked to the lower attachment strip 122. The upper attachment strip 120 and lower attachment strip 122 are pivotally related to each other about an axis 146 which may be a single, fixed axis, or a compound axis to mimic certain natural joint movement.

[0069] Alternatively, the embodiment illustrated in FIGS. 7 and 8 can be integrated with an article of clothing. For example, the exercise assembly 20 may be sewed, adhesively bonded, interfit within, or otherwise connected to the pant leg of a lower garment or the sleeve of an upper garment such that when the garment is worn, the flex zone 40 is positioned in the vicinity of the joint. One or more of the exercise assemblies 20 may be provided per joint, such as one on the lateral side and one on the medial side. Attachment may be conveniently provided by stitching through the aperture 124, 130 etc. to a fabric garment.

[0070] As a further alternative, the exercise assembly 20 of FIGS. 7 and 8 may be attached to a tubular sleeve, such as a woven fabric or flexible polymeric material, having a length of less than a complete pant leg or less than a complete long sleeve of a shirt. Thus, the tubular exercise device may be pulled onto the arm or leg and positioned in the vicinity of the joint, to hold the passive exercise device 20 in position across the joint. In this manner, the passive exercise device may be readily pulled on or off of the wearer, and then covered by conventional clothing if desired.

[0071] In any of the foregoing embodiments, it may be desirable to provide a release which disengages the resistance to movement upon an abrupt increase in force from the wearer. The release may be in the form of a releasable detent or interference joint which can be opened by elastic deformation under force above a preset threshold which is set above normally anticipated forces in normal use. If a wearer should stumble, the reflexive movement to regain balance will activate the release and eliminate resistance to further movement, as a safety feature.

What is claimed is:

1. A low profile, passive exercise device, configured to elevate aerobic metabolic activity in the absence of the device, through a range of normal movement between a first region of the body and a second region of the body, comprising:
   a first attachment structure, for attachment with respect to a first region of the body;
   a second attachment structure, for attachment with respect to a second region of the body which is movable throughout an angular range with respect to the first region;
   a flex zone between the first and second attachment structures;

   wherein the flex zone imparts bidirectional resistance to movement between the first and second regions of the body, throughout a range of motion.

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