BALANCE ASSESSMENT SYSTEM

A body movement assessment device for measuring a position of a center of gravity of a person at a plurality of time intervals relative to a recordable event, such as ball impact in a golf swing, and displaying those measurements for analysis. The body movement assessment device is useful in analyzing the tempo of body movement of a person, the consistency of body movement over two or more repetitions of a movement, the weight shift and postures of the person, and balance of the person. The body movement assessment device may include a visual recording device that enables a visual image of the person to be recorded and replayed together with other analytical information for increased analysis and understanding by the person. In at least one embodiment, the body movement assessment device may be configured to analyze a golf swing.
FIG. 2

FIG. 3
FIG. 6

FIG. 7
FIG. 8

Main Menu

Player Information
Name: Player
Height: 5' 10" (default/adjustable)
Handicap: (optional)
Right Handed

Balance Training
- RIGHT & LEFT BALANCE
- TOES & HEELS BALANCE
- TOTAL WEIGHT BALANCE
- CORNER BALANCE

Swing Training
- SWING TRAINER
- PITCHING
- CHIPPING & PUTTING
- Exit

Instructor (optional)
- PROFESSIONAL GOLF INSTRUCTOR
- DYNAMIC BALANCE SYSTEM
- Hometown, USA [800] 555-1212

FIG. 9
Balance Training

Corner Weight

FIG. 10

Balance Training

Toes & Heels

FIG. 11
**FIG. 12**

Balance Training

**Left & Right**

- 100% 75% 50% 25% 0%
- 27%

**RIGHT**

- 0% 25% 50% 75% 100%

Sound Off

**FIG. 13**

Balance Training

**Total Weight**

- 100% 75% 50% 25% 0%

**TOES**

- 35%

**LEFT**

- 100% 75% 50% 25% 0%

**RIGHT**

- 0% 25% 50% 75% 100%

- 36%

Sound Off

**HEELS**

100%
FIG. 14

FIG. 15
BALANCE ASSESSMENT SYSTEM

FIELD OF THE INVENTION

[0001] The invention relates to balance assessment of a person during an athletic activity, and more particularly, to the balance assessment of a person to heighten body coordination skills critical to maximizing the power and accuracy of movements during athletic activities.

BACKGROUND

[0002] Many exercise performances, such as athletic activities, are focused, in part, on participants’ abilities to repeatedly contact a ball or release a ball in a particular manner. For instance, golf, baseball, and softball include ball contact as a major portion of the games, and basketball, football, baseball, and softball, include ball release actions. Participants who excel in these activities often possess a number of attributes that, when combined, enable those participants to hit or throw a ball further, straighter, and more accurately than other competitors. One factor that typically plays a major part in whether a person excels in an athletic activity is the person’s balance during the athletic activity. In particular, if a person maintains the proper balance throughout an athletic activity, the person has created a good foundation from which the person may perform at a high level and prevent injuries from developing from unnatural movements and from overcompensating for poor balance. In addition, proper weight transfer, which is required in some athletic movements, enables a person to transfer the maximum momentum from the person to the ball.

[0003] Analytical devices have been developed to analyze the movement of the center of gravity of a person through an exercise performance. For instance, U.S. Pat. No. 5,697,791 discloses an analytical device for measuring the center of gravity of a person while hitting a golf ball or performing other athletic activities or exercise performances and displaying the center of gravity on a display screen. The display screen shows the path of the center of gravity for a period of time before and after a ball strike. The analytical device may be used to identify faults in portions of the person’s swing so that the person may focus training efforts on those areas to improve the person’s swing.

[0004] While conventional systems have assisted people in identifying poor balance during a golf swing and other athletic movement, conventional systems have not addressed other factors that affect an athletic movement. For instance, conventional systems have not addressed analyzing the tempo of athletic movements, which is often a major factor in a successful athletic movement. In addition, while conventional systems provide a good basis for analysis, the conventional systems typically do not include elements that facilitate rapid teaching of a well-balance movement to users. For at least these reasons, there exists a need for an improved system for assessing the balance and movement of a person engaged in an exercise performance, such as an athletic movement or position.

SUMMARY OF INVENTION

[0005] This invention is directed to a body movement assessment device usable to record and display the center of gravity of a person while performing a movement or body position and to enable a person to become more consistent at repeating that movement or body position. For instance, the body movement assessment device may be configured to assist a person in analyzing an exercise movement, such as an athletic movement or position. The analysis can improve the person’s balance during the movement or position and enhance the person’s consistency in producing the movement or position. The body movement assessment device may be usable to analyze a recordable event, which may be a number of different events. For instance, the body movement assessment device may be configured to analyze a recordable event such as a ball strike event including, but not limited to, a golf club strike, a baseball bat strike, a softball bat strike, a tennis racket strike, a soccer ball strike, a racket ball racket strike, a hand ball hand strike, a cricket bat strike, a football kick, or others. In addition, the body movement assessment device may be configured to analyze a recordable event such as a ball release event including, but not limited to, a ball throw, a basketball shot, a tennis serve toss, a lacrosse throw, a bowling ball throw, a horseshoe throw, a bowling ball release or others. In still other embodiments, the body movement assessment device may be configured to analyze body movements and balance of horseback riders and others.

[0006] The body movement assessment device may be used as an analytical device to analyze incorrect body balance to facilitate the learning of a more balanced movement. In at least one embodiment, the body movement assessment device may be configured to analyze a golf swing. The body movement assessment device may also be used as a training device to train a person once an analysis has been completed to assist the person in developing good balance. Still yet, the body movement device may be used in physical therapy applications to isolate certain aspects of exercise performances, such as athletic movements, for rehabilitation of disabled athletes.

[0007] The body movement assessment device may include at least one body movement sensor for determining a position of a center of gravity of a person relative to at least one body movement sensor and at least one recordable event sensor for activating storage of data produced by the at least one body movement sensor before or after a recordable event, or both. The body movement sensor may be capable of measuring body movement in two or three dimensions, or both. In at least one embodiment, the body movement sensor is a force plate having a surface configured to support a person standing on the plate. The recordable event sensor may be adapted to movement or position desired to be analyzed. In at least one embodiment, the recordable event sensor may be a microphone for capturing a ball strike event.

[0008] The body movement assessment device may also include at least one display screen for displaying the position of the center of gravity of the person. The center of gravity of the person may be displayed at time intervals before and after the recordable event and at least one central processing unit in communication with the at least one body movement sensor, the at least one recordable event sensor, and the at least one display screen, wherein the central processing unit is configured to record and display on the display screen a plurality of marks representing the position of the center of gravity of a person at time intervals before and after the recordable event, thereby enabling analysis of movement tempo of the person to be analyzed.
The body movement assessment device may also include one or more alarms, which may be visual or audio, or both, for alerting a person that the person has moved into an out of balance position. In at least one embodiment, the alarm may be set off when a person has moved into an out of balance position as signified by a weight percentage in a one of the four quadrants formed of the left toe region, the left heel region, the right toe region, and the right heel region exceeding a predetermined threshold. The threshold for the weight percentages for the alarm may be changed independently for each region, and the alarms for each region may be turned on independently. The alarm for each region may be different than the others so that the person can easily determine in which region the person has placed too much weight.

The body movement assessment device may also include one or more visual recording devices for recording the person during a movement or position. The visual recording may be replayed together with the analytical graphs on the display screen so that the person may be analyzed visually and analytically together. This configuration greatly accelerates learning because the person is able to see at what stages of the swing the person is out of balance.

The body movement assessment device may also display the movement of the center of gravity of a person at various time intervals rather than continuously. The body movement assessment device may produce a trace of the center of gravity formed from a plurality of marks representing the center of gravity for a period of time before and after a recordable event. Each mark forming the trace signifies a position of the center of gravity of the person at a time interval relative to the recordable event. For instance, in at least one embodiment, the body movement assessment device may display a plurality of marks representing the center of gravity of a person during a golf swing for a period of time before or after a ball strike, or both. The marks may represent the positions of the center of gravity taken at intervals of 1/100 of a second over a time period of two seconds before the ball strike until one second after the ball strike. Displaying the center of gravity in this manner enables the tempo of the golf swing to be analyzed. In has been recognized that most good golfers maintain the same tempo from shot to shot with the same club and the same tempo with all clubs, from a wedge to a driver. Thus, it is advantageous to analyze the tempo of a person’s golf swing to assist the person in maintaining consistency of the swing tempo in all shots, thereby enabling the golfer to develop a more consistent golf game.

Another advantage of the invention is that the alarm function enables a person to determine whether the person has fallen out of balance very easily. Conventional systems typically require a person to be viewing a monitor to determine whether the person has fallen out of balance, which at times, forces the person to be placed into an unnatural position. In the instant invention, the person may be alerted that the person has fallen out of balance through an audible alarm. Thus, the person can maintain focus on the ball in a natural position, rather than unnaturally viewing a monitor while swinging at the ball. Enabling the person to maintain a natural position can greatly assist the person in determining where the problem areas in his swing exist more rapidly. In addition, the alarms may be used not only for analysis but also for training exercises to remove bad habits, such as reverse pivots, weight transfers not along the sagittal plane, and others.

Yet another advantage of the invention is that the person may review a swing in numerous manners simultaneously. More specifically, the person may review a swing by watching a replayed visual recording of the swing that is in time with analytical information showing the percentage of weight in each of the quadrants of the feet and showing the location of the person’s center of gravity relative to the sagittal plane. The visual recording may be replayed at normal speed, a slower speed, a faster speed, or paused to assist the analysis. The visual recording improves upon the center of gravity testing by giving a person a chance to determine whether the person’s posture is correct in addition to having a balanced stance with weight properly distributed. A person can be properly balanced but at the same time have bad posture as he steps to the ball in a golf situation or vice versa.

Another advantage of this invention is that the alarms and the display screen enable a person to identify and learn to stay within a “balance zone” to increase the person’s ability to repeat a particular movement or position consistently without exceeding such zone and suffering from increased stress on the body resulting from over compensation.

These and other embodiments are described in more detail below.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic diagram of a body movement assessment device including aspects of this invention.

FIG. 2 is another schematic diagram of the body movement assessment device including aspects of this invention.

FIG. 3 is a schematic perspective diagram displaying aspects of this invention.

FIG. 4 is a perspective view of an embodiment of the body movement assessment device.

FIG. 5 is a perspective view of another embodiment of the body movement assessment device that is portable.

FIG. 6 is a screen shot of a two dimensional display of the position of a center of gravity of a person conducting a balanced golf swing relative to a sagittal alignment reference.

FIG. 7 is a screen shot of a two dimensional display of the position of a center of gravity of a person conducting a poorly balanced golf swing relative to a sagittal alignment reference.

FIG. 8 is another screen shot of a two dimensional display of the position of a center of gravity of a person conducting another poorly balanced golf swing relative to a sagittal alignment reference.

FIG. 9 is a screen shot displaying screen/mode options of the body movement assessment device.

FIG. 10 is a screen shot displaying percentages of weight of a person in each of the quadrants including a left toe region, a left heel region, a right toe region, and a right heel region.
FIG. 11 is a screen shot displaying the percentage of weight of a person in the toe and heel regions.

FIG. 12 is a screen shot displaying the percentage of weight of a person in the left and right feet.

FIG. 13 is a screen shot displaying percentages of weight of a person in each of the quadrants including a toe region, a heel region, a right foot region, and a left foot region in graph form.

FIG. 14 is a screen shot displaying a two dimensional display of the position of a center of gravity of a person conducting a golf swing in a chipping/putting mode which has increased body movement sensitivity usable for stability training and includes weight percentages for each quadrant in each corner of the two dimensional display.

FIG. 15 is a screen shot displaying a two dimensional display of the position of a center of gravity of a person conducting a golf swing in a training mode and including weight percentages for each quadrant in each corner of the two dimensional display.

FIG. 16 is a screen shot displaying two golf swings overlaid to compare movement patterns and determine swing consistency.

FIG. 17 is a screen shot displaying a two dimensional display of the position of a center of gravity of a person conducting a golf swing in a training mode and includes weight percentages for each quadrant in each corner of the two dimensional display.

FIGS. 18-25 display a person at various stages of a golf swing and the corresponding trace produced on the display screen of the body movement assessment device.

FIG. 26 is a screen shot displaying a two dimensional display of the position of a center of gravity of a person conducting a golf swing in a training mode and including weight percentages for each quadrant in each corner of the two dimensional display and a track of the center of gravity of the person.

FIG. 27 is similar to FIG. 14 and further includes arrows that indicated the direction of shear force created by a person’s foot in the four quadrants.

FIG. 28 is similar to FIG. 15 and further includes arrows that indicated the direction of shear force created by a person’s foot in the four quadrants.

DETAILED DESCRIPTION OF THE INVENTION

As shown in FIGS. 1-28, the invention is directed to a body movement assessment device 10 for measuring a position of a center of gravity 12 of a person 14 at a plurality of time intervals relative to a recordable event and displaying those measurements so that the movements of the person 14 may be analyzed. The body movement assessment device 10 is useful in determining consistency of body movement of a person undertaking body movements, such as athletic body movement in, for instance, a sport. In at least one embodiment, the body movement assessment device 10 may be useful in analyzing a golf swing of the person 14 to determine the position of the center of gravity 12 of the person at various points during the swing and to determine the tempo of the swing at various times during the swing and to analyze the person’s posture. The body movement assessment device 10 is also useful to determine the consistency of the person’s 14 movement between two or more different swings.

The following description of the body movement assessment device 10 is described in an embodiment configured to be used in analyzing a golf swing. However, the body movement assessment device 10 is not limited to analyzing a golf swing but may be configured to analyze other body movements as well. For instance, the recordable event from which the analysis may be made may be a ball strike event such as, but not limited to, a golf club strike, a baseball bat strike, a softball bat strike, a tennis racket strike, a soccer ball strike, a racket ball racket strike, a hand ball hand strike, a cricket bat strike, a football kick, or others. In other embodiments, the recordable event may be a ball release event such as, but not limited to, a ball throw, a basketball shot, a tennis serve toss, a lacrosse throw, a bowling ball throw, a horseshoe throw, a bowling ball release, or others. In still other embodiments, the body movement assessment device 10 may be configured to analyze body movements and balance of horseback riders.

As shown in FIGS. 1, 2, 4 and 5, the body movement assessment device 10 may include one or more body movement sensors 16 for determining a position of the center of gravity 12 of the person 14. The body movement assessment device 10 may be formed from different devices depending on the body movement to be analyzed. The body movement assessment device 10 may measure a center of gravity 12 of a person 14 in three dimensions or in two dimensions. In embodiments in which three dimensional analysis is performed, measurements may be made using light sensing devices or other appropriate devices. In an embodiment configured to measure the center of gravity 12 of a person 14 in two dimensions, the body movement sensor 16 may be a force plate 20 having a surface 18 for supporting the person 14. The force plate 20 may measure forces transmitted from the person 14 to the plate 20 and transmit those measurements to a central processing unit 22. The force plate 20 may measure forces from a person 14 when the person 14 is standing on a surface 18 of the plate 20.

The force plate 20 may be configured to measure forces in all areas of the feet of the person 14 such that the measured forces transmitted to the central processing unit 22 may be used to calculate the center of gravity 12 of the person 14 and to calculate the percentage of weight of the person 14 in various portions of the feet of the person 14. In at least one embodiment, the force plate 20 measures forces such that the central processing unit 22 may determine the percentage of weight of a person in each quadrant, wherein the quadrants may be formed from left foot toe region 25, left foot heel region 27, right foot toe region 29, and right foot heel region 31. In other embodiment, the central processing unit 22 may calculate the weight percentages on the heels or toes of the person’s feet or on the left or right feet. The force plate 20 may be positioned proximate to a ball support system 32, as shown in FIGS. 3-5. The force plate 20 and the ball support system 32 may include an artificial turf having a grid 34 for accurately positioning of the feet of the person 14 on the force plate 20 and may include a grid 36 surrounding a tee 38 for supporting a ball. The grid 36 may be used to facilitate the person 14 addressing the ball properly and consistently.
[0040] Measurement of body movements may be controlled by the central processing unit 22 in cooperation with one or more recordable event sensors 24. The central processing unit 22 may be any processing unit capable of performing the necessary calculations to determine the center of gravity 12 of a person 14, such as, but not limited to, a microprocessor, a personal computer, or other appropriate devices. The recordable event sensor 24 determines when the person has performed a recordable event, such as listed above. For instance, in an embodiment in which the body movement assessment device 10 is configured to be used to analyze a golf swing, the recordable event sensor 24 may be a microphone 26 usable to determine when ball strike occurs, such as when a club face strikes a golf ball 40. The microphone 26 may transmit the sound of the ball strike to the central processing unit 22 to record the moment in time that the ball strike occurred. In other embodiments, the recordable event sensor 24 may be a laser for detecting movement of a ball or other object desired to be struck, a pressure sensor to determine a release of an object, such as a ball, or other appropriate devices.

[0041] The body movement assessment device 10 may also include one or more display screens 28 for displaying a position of the center of gravity 12 of the person 14 at time intervals before and after a recordable event. The display screen 28 may enable the person 14 to view various screens, as shown in FIGS. 9-17, which are described below in more detail. In at least one embodiment, the display screen 28 may display two or more screens simultaneously. The display screen 28 is not limited to a particular size or configuration. Rather, the display screen 28 may be any display screen capable of displaying the screen shots shown in FIGS. 9-17 and other information.

[0042] The body movement assessment device 10 may also include one or more visual recording devices 30 for recording movement of the person 14 before and after the recordable event. The visual recording device 30 may be coupled to the central processing unit 22 or to the display screen 28, or both, to display recordings of the person 14 for analysis. In at least one embodiment, the body movement assessment device 10 may include a plurality of visual recording devices 30 for recording movement of the person 14 from different angles. For instance, a person 14 positioned to engage in a golf swing may be recorded from a location facing the person 14, from behind the person, from a position to the right of the person 14, a position to the left of the person 14, or above the person 14, or any combination thereof, or in other positions as well. The recordings may be reviewed on one or more display screens 28. In at least one embodiment, the visual recordings may be reviewed together with other analytical screens shown in FIGS. 9-17 so that the person 14 may see the body position in good balance positions and in poor balance positions to facilitate the person 14 learning proper balance and weight transfer throughout the golf swing. The body movement assessment device 10 may be configured such that the visual recording may be paused at any moment during playback throughout the recorded swing and shown together with the analytical information shown in FIGS. 9-17 correlating to that particular point in the swing, thereby enabling visual and analytical information of the swing to be analyzed together. Such a display tremendously accelerates the learning process for correcting bad habits and teaching a well-balanced golf swing.

[0043] The body movement assessment device 10 may also include one or more alarms 50 for alerting the person 14 that the person has moved to an out of balance condition. For instance, in at least one embodiment, the device 10 may include an alarm 50 for each of the quadrants, including the left foot toe region 25, left foot heel region 27, right foot toe region 29, and right foot heel region 31. The alarm 50 may be actuated for each quadrant independently. In addition, the threshold for each alarm 50 may be established independent of the threshold for alarms 50 for other quadrants. For instance, an alarm 50 for the left foot toe region 25 may be turned on and set for 40 percent such that when the left foot toe region 25 exceeds 40 percent of the weight of the person 14, the alarm is activated. The alarm 50 may be an audible or visual alarm, or both. In at least one embodiment, the alarm 50 includes an audible noise and a flashing of the portion of a graph on the display screen 28 correlating to the particular quadrant in which the weight percentage has been exceeded. The alarms 50 may include an audible alarm for each quadrant that is distinctly different from the other quadrants 50. Such a configuration is particularly advantageous because it allows the person 14 to get into a ready position without looking up to view the display screen 28. In addition, and most importantly, the person 14 may perform a golf swing without looking at the display screen 28 and be notified audibly whenever the person 14 exceeds a weight percentage in one of more of the quadrants. This is particularly useful because a person 14 may stay in the person's normal golf swing posture and swing naturally and yet be told if the person 14 falls out of balance during the swing.

[0044] In addition, a golf instructor can use the body movement assessment device 10 to correct bad habits in a golf swing of a person 14. For instance, a golf instructor may use the device 10 to cue a reverse weight shift where a person 14 incorrectly shifts weight to the back foot, which is the right foot for a right handed golfer, at ball contact. The instructor can set the thresholds such that the person 14 must set off the alarms 50 for the left foot in order to perform create a proper weight transfer. Thus, the person 14 must continue to transfer weight to the left foot during the swing until the person 14 hears the alarms 50 activate. Without activation of the alarm 50, proper weight transfer has not been taken place.

[0045] The body movement assessment device 10 may also measure shear forces developed by the feet of the person 14 standing on the force plate 20 during movement. The shear forces may be measured using any conventional shear stress sensor, as known to those of ordinary skill in the art. The shear forces that are measured may be displayed in screen shots, as shown in FIGS. 27 and 28. More specifically, FIG. 27 displays a center of gravity display together with arrows 66 corresponding with each of the four quadrants previously described. The arrows 66 indicate the direction of shear force. In addition, a plurality of dots 68, or other shape or method, may be shown on the display screen 28 to indicate the amount of shear force exerted in a particular quadrant. Each dot 68 may represent an increment of force, such as, but not limited to five pounds. FIG. 28 displays arrows 66 used to indicate a direction of shear force created by a person's 14 foot and the magnitude of that shear force. The magnitude of the shear force may be indicated by the length of the arrow. The larger the shear force measured, the longer the arrow may be displayed, and vice versa.
[0046] During use, the body movement assessment device 10 may be used to trace the center of gravity 12 of a person throughout a golf swing, as shown in FIGS. 18-25. The body movement assessment device 10 is actuated by first turning the device 10 on. A golf ball 40 may be placed on the turf or a tee 38 in of the ball support system 32. The horizontal and vertical position of the surface 18 of the body movement sensor 16 relative to the ball support system 12 may be adjusted to simulate an uphill lie, a down hill lie, or other shots encountered on a golf course. The person 14 steps onto the body movement sensor 16. As shown in FIG. 3, the person 14 may position his feet generally symmetrically on the grid 34 relative to the longitudinal alignment line 34 and the right and left lateral lines 44, 46. For instance, the person 14 may stand on the body movement sensor 16 such that ankle joints of the person 14 are positioned over a longitudinal alignment line 42, which positions the ankle joints of the person 14 relative to the front and back boundaries of the body movement sensor 16. Spacing of the feet relative to the boundaries of the body movement sensor 16 are indicated by positions of the feet relative to the right lateral alignment line 44 and the left lateral alignment line 46. An arrow 48 shows the desired direction of ball flight, which is generally parallel to the longitudinal alignment line 42.

[0047] When the person 14 stands on the body movement sensor 16, the display screen 28 displays the screen shot shown in FIG. 17. The center of gravity 12 is displayed on the screen 28. In at least one embodiment, the center of gravity 12 is not displayed as a continuous line. Rather, the center of gravity 12 is displayed at time intervals and forms a dotted line as shown in FIGS. 6-8 and 14-17. The dotted line conveys the movement path of the center of gravity 12 of the person 14 during an event, such as a golf swing. As shown in FIGS. 14-17, the trace displays the center of gravity in relation to a balance zone 52, which extends generally between the left and right feet and between the heels and bridges of the feet. FIGS. 14-17 displays the center of gravity 12 of the person 14 as viewed from above the person 14 and relative to the sagittal alignment reference 54, which represents the longitudinal alignment line 42. While golf swings typically differ from person to person, most good golf swings have a corresponding center of gravity 12 that does not travel outside of the balance zone 52.

[0048] The tracing aspect of the body movement assessment device 10 enables a person to understand the body movements that are not consistent with good golf. The tracing aspect enables a person 14 to better understand the position of the body throughout a golf swing.

[0049] Second, the dotted trace conveys the position of the center of gravity 12 at consecutive time intervals, such as, but not limited to, 1/100 of a second. In other embodiments, the time intervals may be less than or greater than 1/100 of a second. Displaying the center of gravity 12 of the person 14 enables the rate, or tempo, of movement of the person 14 to be analyzed. Dots that are positioned close together indicate slower movement than dots that are positioned further apart. The tempo of one golf swing by a person 14 may be compared with the tempo of a golf swing from the same person 14 with the same or different club. It has been determined that many excellent golfers typically have a very consistent tempo from shot to shot and throughout all clubs, from wedges to drivers. Thus, analyzing the consistency of the tempo of a golf swing of a golfer is useful.

[0050] In at least one embodiment, the center of gravity 12 may be displayed in one manner when the person 14 is moving in a first direction along the longitudinal alignment line 42 and may appear in a different manner when the person 14 is moving in a second direction that is generally opposite to the first direction. This configuration facilitates easy analysis of the swing shown in FIGS. 14-17, which displays the trace of the movement of the center of gravity 12 of a person through a golf swing. In at least one embodiment, the center of gravity 12 may be displayed in a first color when the person 14 is moving in a first direction along the longitudinal alignment line 42 and may appear in a different color when the person 14 is moving in a second direction that is generally opposite to the first direction. Alternatively, rather than different colors, the dots representing the center of gravity 12 in one direction may be represented by a symbol that is distinguishable from a symbol used to represent movement of the center of gravity 12 in a direction generally opposite to the first direction.

[0051] The person 14 may address the ball 40 positioned on the ball support system 32. The visual recording device 30 and the body movement sensor 16 record information while the person 14 is standing on the body movement sensor. The person 14 may proceed with a typical golf swing. The body movement sensor 16 records the forces generated by the person 14 during the swing and transmits the data to the central processing unit 22, which calculates the center of gravity 12 of the body movement assessment device 10. The central processing unit 22 also calculates the percentage of weight of the person in each of the regions 25, 27, 29, and 31 and displays it on the display screen 28. As the golf swing is made, the center of gravity 12 may be displayed on the display screen 28, as shown in FIGS. 14-17. In the example of a golf swing, the ball strike is the recordable event. The recordable event sensor 24 transmits the ball strike to the central processing unit 22.

[0052] Once the person 14 has completed the swing, the central processing unit 22 produces a window of data that correlates to data created by the person 14 before the ball strike, which is the recordable event, and after the ball strike so that the person 14 may analyze the swing before and after the swing. In at least one embodiment, the central processing unit 22 produces data correlating to two seconds before the ball strike event to one second after the ball strike event. However, in other embodiments, the time frame of data produced by the central processing unit 22 may vary. As shown in FIGS. 1 and 2, the central processing unit 22 may produce data to display a dotted trace representing the path of the center of gravity 12 for a time period and may display an X or other appropriate mark 60 marking the location of the center of gravity 12 at the recordable event, which in this case is at the time the club impacts the ball 40.

[0053] FIG. 6 shows a screen shot of a two-dimensional display screen 28. The center of gravity 12 marks are shown relative to the sagittal alignment reference 54, which corresponds to the longitudinal alignment line 42, and the lateral dimension of the display screen 28 corresponds to the left-right axis of the person 14. During a well-coordinated golf swing, the direction of ball flight should approximately correspond to the sagittal alignment reference 54 and remain...
within the balance zone 52. The center of gravity 12 begins at a calculated start-time 56 before a recordable event and continues until a calculated stop-time 58. A mark 60 designates the center of gravity 12 corresponding with the ball-strike.

[0054] The screen shot shown in FIG. 6 displays a well-coordinated golf swing. The center of gravity 12 of the person 14 at the beginning of the swing is centered relative to the sagittal alignment reference 54 and lateral references 44, 46. During the back swing of the person 14, the center of gravity 12 moves to the right lateral line 44, and during the forward swing, the center of gravity 12 moves toward a center position on the sagittal alignment reference 54 between the lateral references 44, 46. After ball strike in the follow through portion of the swing, the center of gravity 12 moves to the left lateral line 46. By moving the center of gravity 12 generally along the sagittal alignment reference 54, the person 14 moves the center of gravity 12 in a straight line aligned with the desired direction of ball-flight. In addition, moving the center of gravity 12 the full distance between the right and left lateral lines 44, 46 and by striking the ball while generally centered between the lateral lines 44, 46, the person 14 is performing an advantageous weight shift.

[0055] In contrast, FIG. 7 is a screen shot displaying a poorly balanced golf swing. Initially, the center of gravity 12 of the person 14 is centered relative to the sagittal alignment reference 54 and lateral lines 44, 46. During the back swing, however, the center of gravity 12 moves away from the sagittal alignment reference 54. As the person 14 begins the forward portion of the swing, the center of gravity 12 moves toward the sagittal alignment reference 54 and the ball 40 is struck before the center of gravity 12 is centered between the lateral lines 44 and 46. After ball contact, the center of gravity 12 moves away from the sagittal alignment reference 54. Movement of the center of gravity 12 shown in FIG. 7 is not in line with the desired direction of ball flight, thereby reducing the likelihood of a good shot. In addition, striking the ball 40 before the center of gravity 12 is centered between the lateral lines 44 and 46 prevents the person 14 from transferring maximum momentum to the ball 40.

[0056] FIG. 8 also displays a poorly balanced golf swing in which the person 14 fails to go through a proper weight shift. In particular, the person 14 fails to move the center of gravity 12 the full distance to the right lateral line 44, and at the completion of the swing after follow-through, the person 14 fails to shift the center of gravity 12 the full distance to the left lateral line 46. Failure to shift the center of gravity 12 the full distance between the lateral lines 44, 46 prevents the person 14 from imparting the maximum forward momentum to the ball 40.

[0057] The swing of the person 14 may be analyzed in numerous manners. For instance, the tempo of the swing, the balance of the person 14, and the visual recording of the person 14 may be analyzed. The person 14 may also swing multiple times and compare the multiple swings on a single display screen 28, as shown in the screen shot in FIG. 16. This comparison enables a conclusion to be made regarding the consistency of weight transfer during the swing of the person 14. Typically, the more consistent the swing of a golfer, the more successful the golfer will be.

[0058] In at least one embodiment, the device 10 may display the visual recording of the person 14 swinging together with the analytical graphs shown in FIGS. 14-17. The display may occur on a single display screen 28 or on multiple screens 28 with the visual recording shown on one screen 28 and the analytical information shown on other screens 28. Furthermore, a person may choose to view a screen, as shown at FIG. 26, that combines the screen shot shown in FIG. 10 that displays percentages of weight of a person in each of the quadrants including a left toe region, a left heel region, a right toe region, and a right heel region with the screen shot shown in FIG. 15 displaying a two dimensional display of the position of a center of gravity of a person conducting a golf swing in a training mode and including weight percentages for each quadrant in each corner of the two dimensional display. Such a combined display will enable a person to whom the data correlates, an instructor, or others, to analyze the person's swing or movement throughout the recorded period.

[0059] With the integrated approach of video and audio analysis in combination with the balance enables a far more sophisticated analysis of the golf swing to be undertaken. Thus, balance alone is not sufficient, but balance analyzed together with overall body posture enables scrutiny on a heretofore unrecognized level. Additionally with balance appropriately being studied, the integration of the movement of center of gravity of the player during critical moves such as the downswing can be carefully analyzed. Additionally audio feedback is added to the device 10 to give a person 14 a measure of consistency of the center of gravity from one golf swing to the next either with the same clubs or different clubs.

[0060] The foregoing is provided for purposes of illustrating, explaining, and describing embodiments of this invention. Modifications and adaptations to these embodiments will be apparent to those skilled in the art and may be made without departing from the scope or spirit of this invention.

I claim:

1. A body movement assessment device, comprising:
   at least one body movement sensor for determining a position of a center of gravity of a person relative to at least one body movement sensor;
   at least one recordable event sensor for activating storage of data produced by the at least one body movement sensor relative to a recordable event;
   at least one display screen for displaying the position of the center of gravity of the person at time intervals relative to the recordable event; and
   at least one central processing unit in communication with the at least one body movement sensor, the at least one recordable event sensor, and the at least one display screen, wherein the central processing unit is configured to record and display on the display screen a plurality of marks representing the position of the center of gravity of a person at time intervals relative to the recordable event, thereby enabling analysis of movement tempo of the person to be analyzed.

2. The body movement assessment device of claim 1, wherein the at least one body movement sensor comprises at least one force plate with at least one flat surface for supporting a person.

3. The body movement assessment device of claim 1, wherein the recordable event sensor is capable of being
activated upon detecting a ball strike event and the recordable event is the ball strike event.

4. The body movement assessment device of claim 3, wherein the ball strike event is selected from the group consisting of a golf club strike, a baseball bat strike, a softball bat strike, a tennis racket strike, a soccer ball strike, a racket ball racket strike, a hand ball hand strike, a football kick, and a cricket bat strike.

5. The body movement assessment device of claim 1, wherein the recordable event sensor is adapted to be activated upon detecting a ball release event and the recordable event is the ball release event.

6. The body movement assessment device of claim 5, wherein the ball release event is selected from the group consisting of a ball throw, a basketball shot, a tennis serve toss, a lacrosse throw, a bowling ball throw, a bowling ball release, and a horseshoe throw.

7. The body movement assessment device of claim 1, wherein the time interval between center of gravity measurements is about in 1/100 of a second.

8. The body movement assessment device of claim 1, further comprising a visual recording device for recording the movement of the person relative to the recordable event wherein the at least one display screen is configured to display the movement and is configured to replay a recording of the movement of the person.

9. The body movement assessment device of claim 8, wherein the central processing unit is capable of displaying on the at least one display screen a screen with center of gravity positions together with a visual recording of the person moving before and after the recordable event.

10. The body movement assessment device of claim 1, wherein the central processing unit is capable of displaying a percentage of weight of the person in contact with the at least one body movement sensor for each of left foot toe region, left foot heel region, right foot toe region, and right foot heel region simultaneously.

11. The body movement assessment device of claim 1, further comprising at least one alarm triggered when the center of gravity of the person moves outside of a predetermined area.

12. The body movement assessment device of claim 11, wherein the at least one alarm is triggered when a threshold weight percentage for one or more center of gravity quadrants for the person is exceeded.

13. The body movement assessment device of claim 12, wherein each center of gravity quadrant includes an alarm that, when actuated, is different from an alarm of other center of gravity quadrants for the person, wherein a threshold for each alarm is adjustable independent of other center of gravity quadrant alarms, and wherein each center of gravity quadrant alarm is independently activated.

14. The body movement assessment device of claim 1, wherein the central processing unit displays marks on the at least one display screen in a first manner indicating movement of the person in a first lateral direction and displays marks on the at least one display screen in a second manner indicating movement of the person in a second, generally opposite, lateral direction.

15. The body movement assessment device of claim 1, wherein the at least one display screen displays percentage of body weight on each foot and a center of gravity track so that both can be analyzed together.

16. The body movement assessment device of claim 1, wherein the at least one display screen displays at least one arrow indicating the direction of shear force produced by a foot of a person.

17. The body movement assessment device of claim 16, wherein the at least one display screen indicates the amount of shear force produced by the foot of a person.

18. A body movement assessment device, comprising:

- at least one body movement sensor having at least one surface for determining a position of a center of gravity of a person relative to at least one body movement sensor;
- at least one recordable event sensor for activating storage of data produced by the at least one body movement sensor relative to a recordable event;
- at least one display screen for displaying the position of the center of gravity of the person;
- a visual recording device for recording the movement of the person relative to the recordable event and wherein the at least one display screen is configured to display the movement and is configured to replay a recording of the movement of the person; and
- at least one central processing unit in communication with the at least one body movement sensor, the at least one body movement sensor, and the at least one display screen, and the visual recording device, wherein the central processing unit is configured to record and display on the display screen a plurality of marks representing the position of the center of gravity of a person at time intervals relative to the recordable event.

19. The body movement assessment device of claim 18, wherein the central processing unit is capable of displaying on the at least one display screen a balance screen with center of gravity positions together with a visual recording of the person moving relative to the recordable event.

20. The body movement assessment device of claim 18, wherein the central processing unit is capable of displaying a percentage of weight of the person in contact with the at least one body movement sensor for each of left foot toe region, left foot heel region, right foot toe region, and right foot heel region simultaneously.

21. The body movement assessment device of claim 18, wherein each center of gravity quadrant includes an alarm signifying that the person is out of balance and that, when actuated, is different from an alarm of other center of gravity quadrants for the person, wherein a threshold for each alarm is adjustable independent of other center of gravity quadrant alarms, and wherein each center of gravity quadrant alarm is independently activated.

22. The body movement assessment device of claim 18, wherein the central processing unit displays marks on the at least one display screen in a first manner indicating movement of the person in a first lateral direction and displays marks on the at least one display screen in a second manner indicating movement of the person in a second, generally opposite, lateral direction.

23. The body movement assessment device of claim 18, wherein the at least one display screen displays percentage of body weight on each foot and a center of gravity track so that both can be analyzed together.
24. The body movement assessment device of claim 18, wherein the at least one display screen displays at least one arrow indicating the direction of shear force produced by a foot of a person.

25. The body movement assessment device of claim 24, wherein the at least one display screen indicates the amount of shear force produced by the foot of a person.

26. A method of analyzing balance and consistency of a person performing an athletic movement, comprising:
   positioning a person in proximity with at least one body movement sensor for determining a position of a center of gravity of the person relative to at least one body movement sensor;
   determining the occurrence of a recordable event using at least one recordable event sensor;
   measuring the center of gravity of the person at a plurality of time intervals before and after a recordable event using the at least one body movement sensor;
   recording the measurements taken of the center of gravity of the person at time intervals in at least one central processing unit;
   displaying on at least one display screen the center of gravity of a person taken at the plurality of time intervals before and after the recordable event as marks enabling a movement tempo of the person to be analyzed.

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