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(54) **METHOD OF SELECTING THE FOOT PLANE ANGLE IN A SLIDING ACTIVITY**

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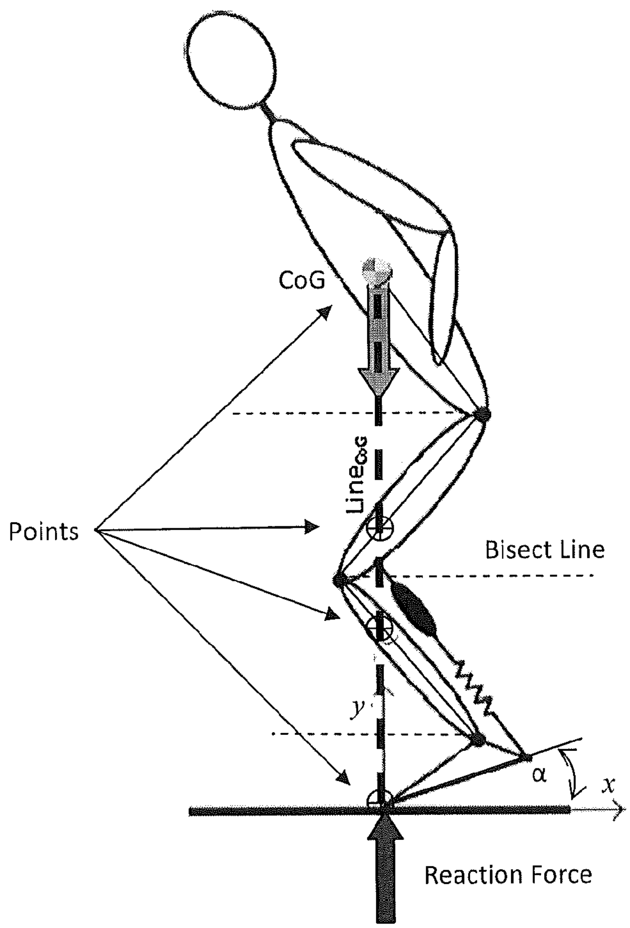
USPC **280/636**; 280/11.3

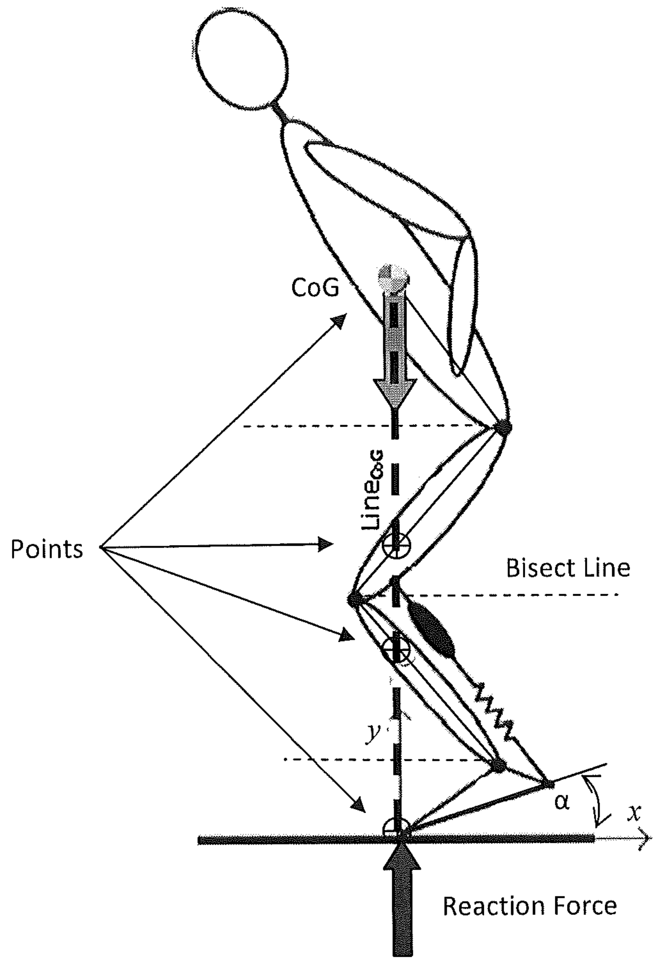
(57) **ABSTRACT**

In various sliding activities or sports, such as ice skating, a desired angle for the foot plane within a boot is selected. When conditions change, such as going to a different location or even changes within the original location such as temperature changes, the original foot plane angle is no longer appropriate to give the best convenience and performance results. In order to determine the more appropriate foot plane angle the friction coefficient of the surface for which the original foot plane angle existed is determined and then the new friction coefficient is measured at the new location or under the changed conditions. The change in initial friction coefficient to the new friction coefficient is then used to determine what change should be made to the foot plane angle.



Balance Sport

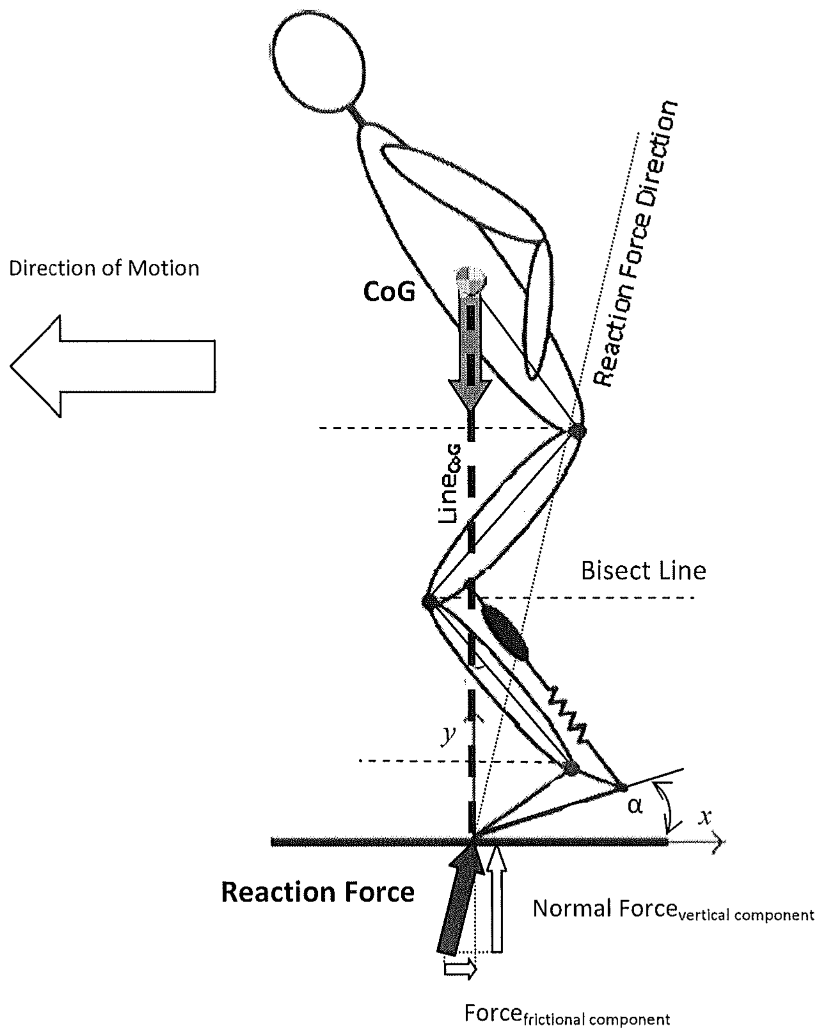
Non-sliding Balanced Position



Balance Sport

Non-sliding Balanced Position

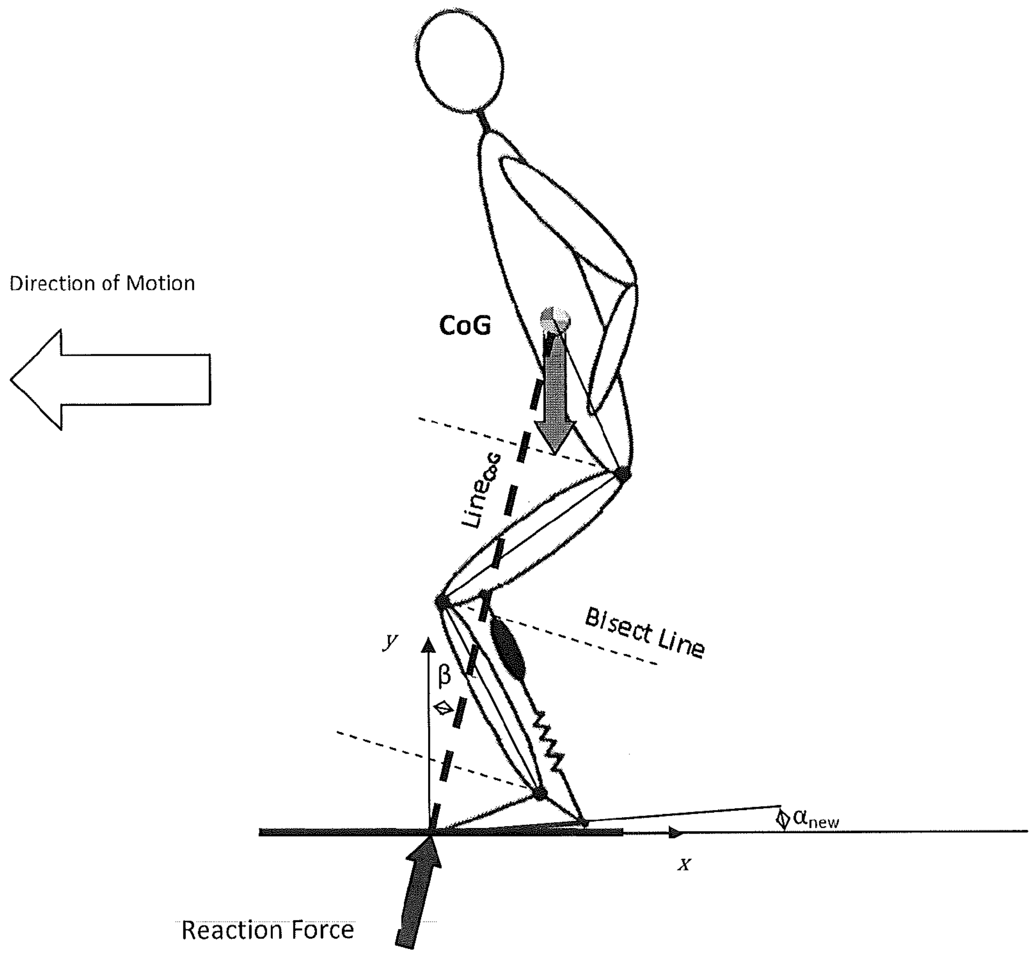
FIG. 1



Sliding Balance Sport

Unbalanced Position

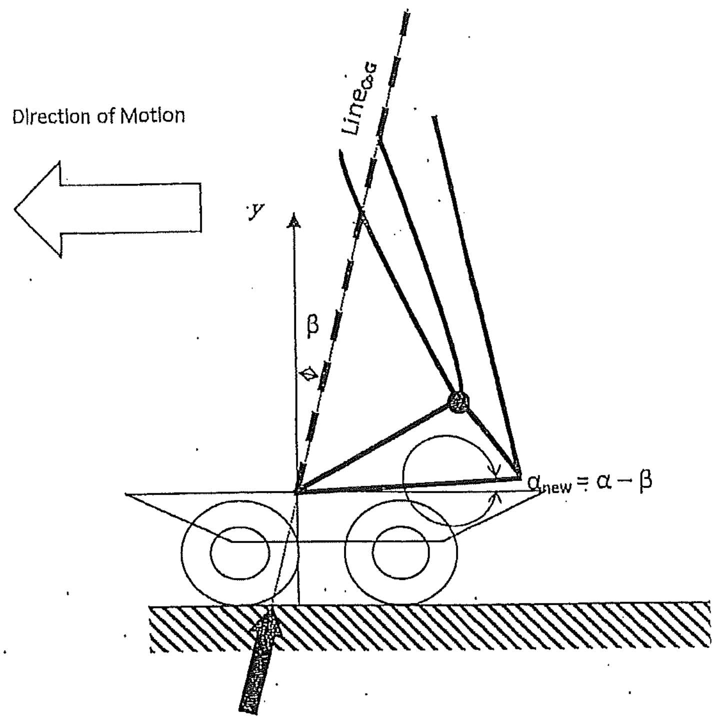
FIG. 2



Sliding Balance Sport

Sliding Balanced Position

FIG. 3



Sliding Balance Sport
Rotationally Stable
Sliding Balanced Position

FIG. 4

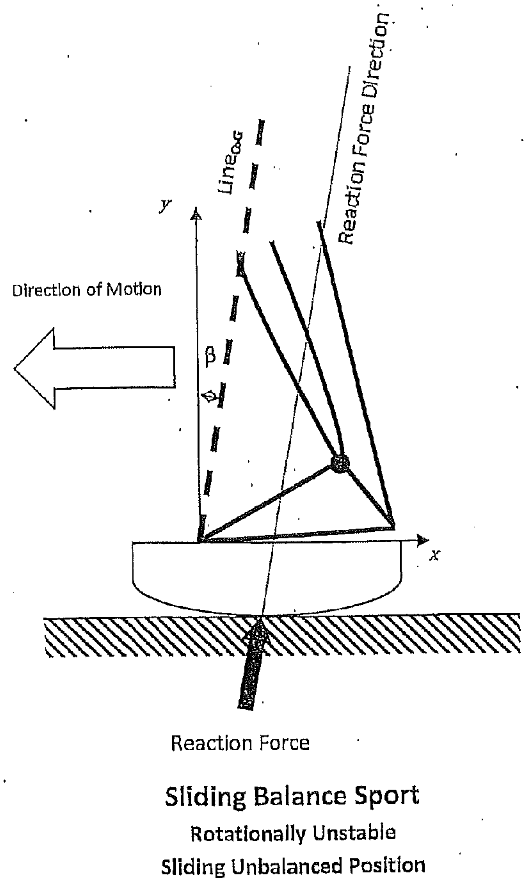

Reaction Force Direction
$Line_{CoG}$
y
Direction of Motion
β
x
Reaction Force
Sliding Balance Sport
Rotationally Unstable
Sliding Unbalanced Position

FIG. 5

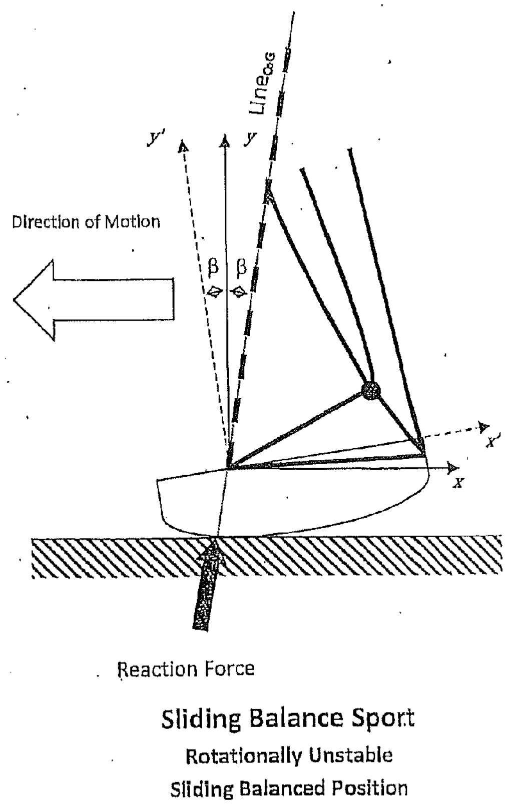

$Line_{CoG}$
y'
y
Direction of Motion
β
β
x'
x
Reaction Force
Sliding Balance Sport
Rotationally Unstable
Sliding Balanced Position

FIG. 6

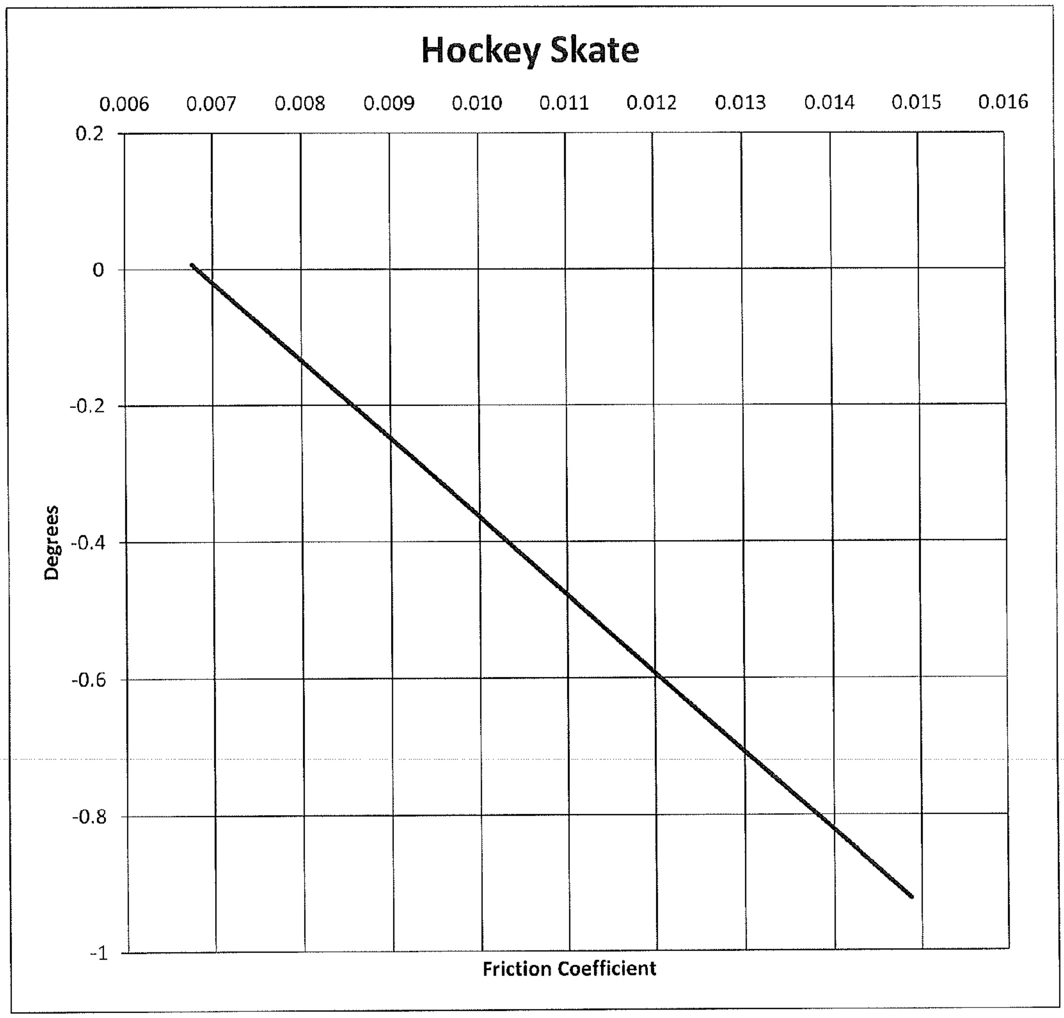

Hockey Skate
0.006
0.007
0.008
0.009
0.010
0.011
0.012
0.013
0.014
0.015
0.016
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
Degrees
Friction Coefficient

FIG. 7

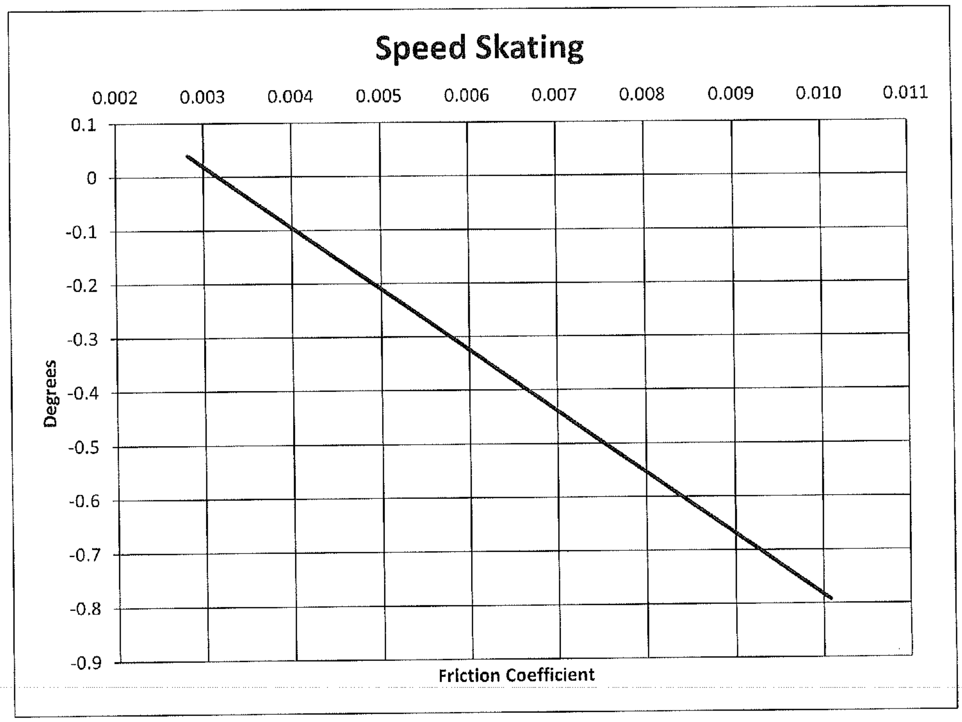

Speed Skating
0.002
0.003
0.004
0.005
0.006
0.007
0.008
0.009
0.010
0.011
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
Degrees
Friction Coefficient

FIG. 8

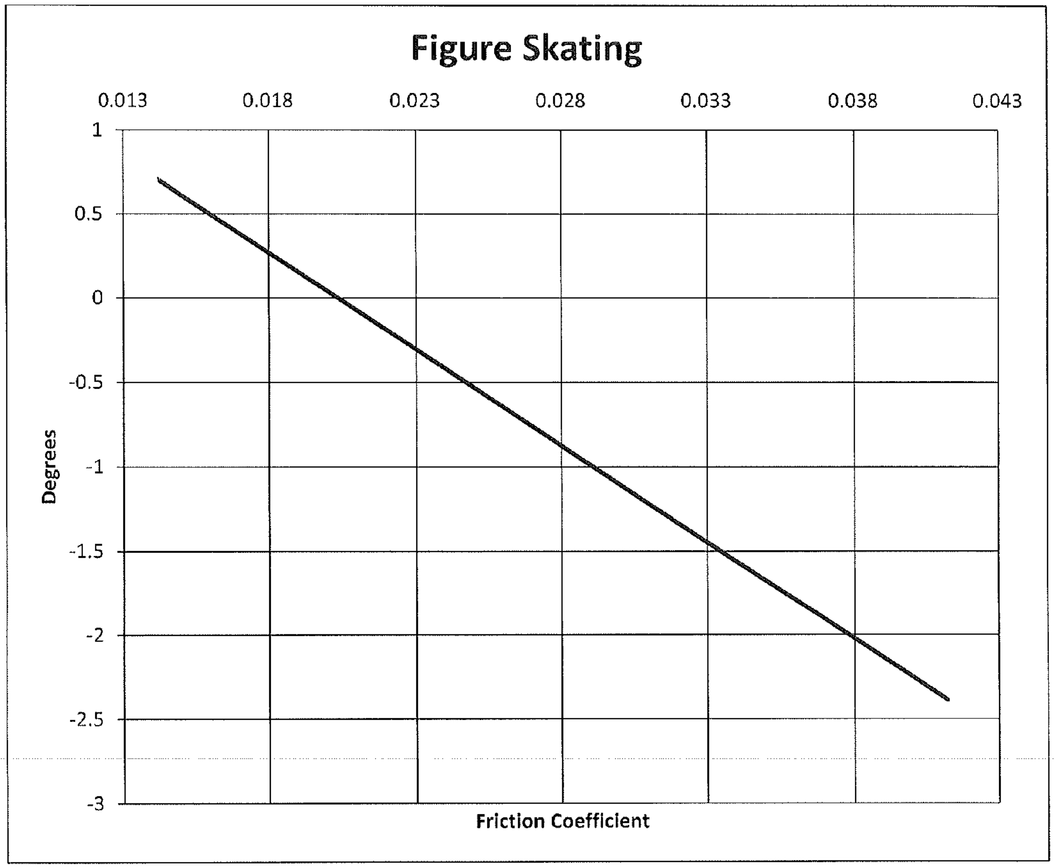


Figure Skating
0.013
0.018
0.023
0.028
0.033
0.038
0.043
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
-3
Degrees
Friction Coefficient

FIG. 9

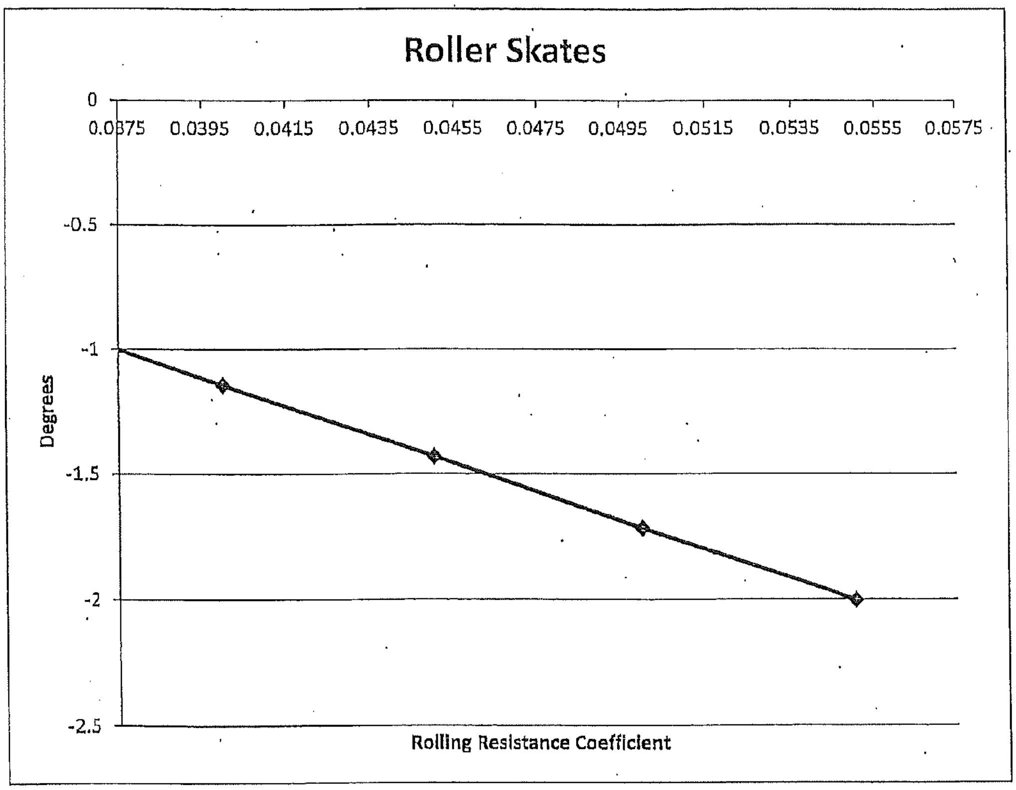

Roller Skates
0
0.0375
0.0395
0.0415
0.0435
0.0455
0.0475
0.0495
0.0515
0.0535
0.0555
0.0575
-0.5
-1
-1.5
-2
-2.5
Degrees
Rolling Resistance Coefficient

FIG. 10

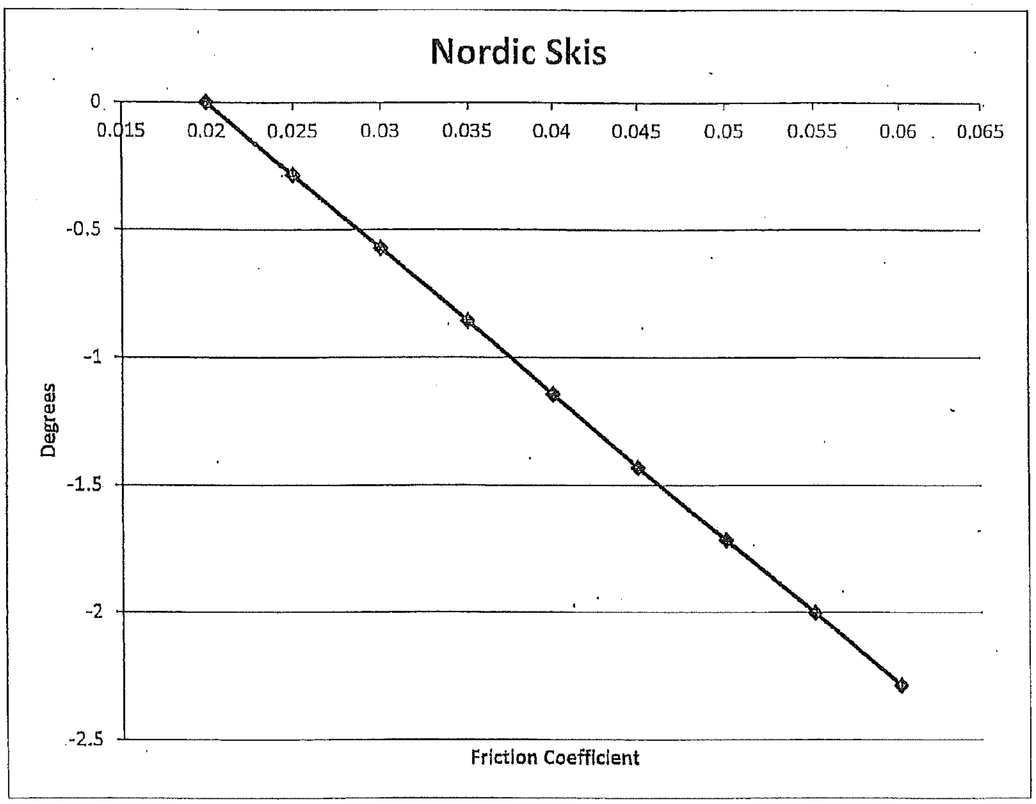

Nordic Skis
0
-0.5
-1
-1.5
-2
-2.5
0.015
0.02
0.025
0.03
0.035
0.04
0.045
0.05
0.055
0.06
0.065
Degrees
Friction Coefficient

FIG. 11

METHOD OF SELECTING THE FOOT PLANE ANGLE IN A SLIDING ACTIVITY

BACKGROUND OF INVENTION

[0001] In various types of sliding activities or sports, such as ice skating, roller skating and skiing, it is desirable to provide the user with boots wherein the foot plane of the user is in an angular position to provide comfort and to optimize performance. It is known from, for example, U.S. Published Application US2013/0062840 to adjust the plane of the skate of the user's foot, such as an ice skater, by placing shims under the heel or under the ball of the foot in the boot. All of the details of that published application are incorporated herein by reference thereto. U.S. Published Application US2013/0001902 also discloses the use of providing shims to adjust the forward pitch of an ice skate. All of the details of that published application are also incorporated herein by reference thereto.

[0002] Initially the desired foot plane angle would be selected which could achieve the desired comfort and performance results. However, if there are changes in conditions, such as performing the activity in a different location or under changed conditions in that same location, the original foot plane angle may no longer provide the best comfort/performance results.

SUMMARY OF INVENTION

[0003] An object of this invention is to provide a method of selecting a foot plane angle in a boot used in a sliding activity such as ice skating, roller skating or skiing.

[0004] A further object of this invention is to provide such a method which takes into account changed conditions and provides guidelines for correspondingly changing or adjusting the foot plane angle.

[0005] In accordance with this invention the friction coefficient is utilized as a guideline for determining the best or change in foot plane angle. This is done by first determining the initial friction coefficient between the boot contact edge/surface and the surface of the sliding activity when the initial foot plane angle had been selected. Later when there is a change in conditions causing a friction coefficient change, such as moving to a different location or there has been a temperature change in the original location, the friction coefficient is again measured. If the friction coefficient increases, then the original foot plane angle would be decreased. If the friction of coefficient decreases then the foot plane angle would be increased.

[0006] The change in foot plane angle could be accomplished in any suitable manner, such as by selection of the proper size shim placed under either the heel or the ball of the foot to thereby elevate or lower the foot plane angle to the desired degree.

THE DRAWINGS

[0007] FIG. **1** illustrates the position of a person in the non-sliding balanced position of a balance sport;

[0008] FIG. **2** illustrates a person in the unbalanced position of a sliding balance sport;

[0009] FIG. **3** illustrates a person in the sliding balanced position in a sliding balanced sport;

[0010] FIG. **4** illustrates the forces for a sliding balanced position in a rotationally stable sliding balanced sport;

[0011] FIG. **5** is a view similar to FIG. **4** of the sliding unbalanced position in a rotationally unstable sliding balanced sport;

[0012] FIG. **6** is a view similar to FIG. **5** of the sliding balanced position in a rotationally unstable sliding balance sport;

[0013] FIG. **7** is a graph correlating the angle adjustment with the change in friction coefficient for a hockey skate in accordance with this invention;

[0014] FIG. **8** is a graph correlating the angle adjustment with the change in friction coefficient for a speed skating skate in accordance with this invention;

[0015] FIG. **9** is a graph correlating the angle of adjustment with the change in the angle of adjustment friction coefficient for a figure skating skate in accordance with this invention;

[0016] FIG. **10** is a graph correlating the angle adjustment with the change in friction coefficient (rolling resistance coefficient) for roller skates in accordance with this invention; and

[0017] FIG. **11** is a graph correlating the angle of adjustment with the change in friction coefficient for Nordic skis in accordance with this invention.

DETAILED DESCRIPTION

[0018] The present invention is based, in part, on the observation that a skater might have a good feeling on the ice one day but not another. Such good feeling means that the skater would not be struggling to hold the technique together and would not be unnecessarily fatigued in doing so. When considering why the feeling might change, the skater's posture and the mechanics of skating are taken into account. The primary concept of skating is balance. Mechanically speaking there is a balance between the forces and torques acting on skaters. The skater feels a force as a pressure which tries to move the skater in one direction or another. A torque is felt as force that tries to rotate the skater in a direction. A force creates a torque if the line of direction of the force does not go through the skater's center of gravity (essentially the belly button).

[0019] Balance is centered about the center of gravity of the skater. When the skater is in the good feeling posture, a conceptual line from the center of gravity to the intersection point of the blade rocker and the ice is collinear with the direction of the resultant force (combining the normal and friction forces). See FIGS. **2** and **3**. Thus, the feeling occurs when the angles between the body's limbs are comfortable and no extra exertion is necessary. When ice friction changes, the direction of this resultant force will change with respect to the horizontal and thus, will not be collinear with the conceptual line. This will cause a torque. The skater must then adjust his/her posture to a more comfortable one to eliminate the torque.

[0020] It has been observed that only a relatively small foot angle change is needed, even for a relatively large friction coefficient change within the realm of the normal skating ice condition. A skater needs only to change the lift by 0.2 mm (the thickness of a file folder) to feel a significant change in the move to or from the good feeling.

[0021] Use of shims or lifts even smaller than 0.2 mm are also felt by the user.

[0022] In various types of sliding activities or sports, such as different forms of ice skating, roller skating or skiing, the good feeling is achieved when foot plane angle is in its optimum position. The foot plane angle is determined by the plane at the sole of the foot (from the heel to ball of the foot) within a boot used for that activity. The angle could be adjusted through the use of shims as described in U.S. Published Application 2013/0062840 or by other methods.

[0023] This invention is directed to a method of determining the most efficient and comfortable plane-of-motion foot plane angle, relative to the ice (sliding surface), for ice skates (or any footwear for standing sliding activity) and then adjusting this angle for changing sliding conditions.

[0024] This is accomplished by first determining the initial balance point for the sliding person and by measuring initial conditions. Then, through certain determinations, when initial conditions change, a new foot plane angle is selected.

[0025] The invention is based upon the following observations.

[0026] With reference to FIG. **1**, looking at a person in profile (xy plane), a conceptual line from the center of gravity to the ball of the foot is considered ($Line_{CoG}$) or Center of Gravity Line. When a person crouches to vertically jump or to pick up an object, on one foot or two, perhaps the most efficient and comfortable maneuver requires that a conceptual $Line_{CoG}$ needs to continuously (through jumping or standing motion) pass through the same point in each of the: torso, upper leg bones, lower leg bones and the foot. The bisect line through the angles formed between lines connecting these body part joints then needs to be perpendicular to the $Line_{CoG}$. During this maneuver, the minimum extent of $Line_{CoG}$ is normally determined from the acute limit of the angle between the lower leg and the foot plane when the foot is in the activity-specific footwear. Thus, an angle "α", as shown in FIG. **1**, is defined as the foot-plane angle relative to the horizontal, when the length of $Line_{CoG}$ is at a minimum and when the person is the non-sliding balanced position wearing his/her activity-specific footwear. While this may be the most efficient and comfortable posture, it is not necessary for use of this invention. Other postures may be considered in the same way.

[0027] In the Non-sliding Balanced Position case of FIG. **1**, the direction of the Reaction Force, from the standing surface, passes through the Center of Gravity, thereby the person is balanced and stable. A shim of angle "a" placed under the heel can relieve the muscle stress in the lower leg and foot in the crouched position.

[0028] If the sliding person maintained the same body posture (relative to the surface) as a non-sliding person, the frictional component of the reaction force at the ball of the foot would make the person unbalanced (FIG. **2** Unbalanced Position). This is because the direction of the reaction force would not be aligned with the $Line_{CoG}$, i.e. through the person's center of gravity; thus there would be a torque acting on the body causing the person to topple forward (assuming that air friction causes no added torque, as it acts approximately through the center of gravity).

[0029] For a person performing friction sliding (e.g. ice skating, skiing, or roller skating), while either maintaining body posture or trying to exert a force through the ball of the foot (as in a glide, jump or push respectively), the most efficient maneuver then would require the person to angularly adjust the $Line_{CoG}$ relative to the sliding surface by positioning the body to maintain rotational balance without changing the relative position of the $Line_{CoG}$ with respect to the body, i.e. for example through the points described above (FIG. **1** Non-sliding Balanced Position); the direction of the reaction force would be through the person's center of gravity and therefore no torque would be acting on the body. Another way of regarding this would be for the person to angularly adjust the $Line_{CoG}$, relative to the sliding surface, by an angle β (FIG. **3** Sliding Balanced Position).

[0030] The change in the angle α, from the FIG. **2** Unbalanced Position to the FIG. **3** Sliding Balanced Position respectively, demonstrates that the foot plane angle would need to be reduced by angle β to maintain the body posture of a balanced person as in FIG. **1**. Therefore $\alpha_{now}=\alpha-\beta$, where

$$\beta = \tan^{-1}\left(\frac{friction_{sliding}}{weight_{person}}\right) = \tan^{-1}(\text{friction coefficient}).$$

[0031] It is noted that the frictional component of the reaction force could be large enough that alpha becomes negative and, if using shims to adjust the foot plane angle, a ball of the foot shim would be needed instead of a heel shim.

[0032] While this formula works well for when the contact surfaces are straight or are rotationally stable in the xy plane, it must be modified when one of the surfaces is curvilinear, such as an ice skate, which is unstable in the xy plane. This is demonstrated in the FIGS. **4-6** Rotationally Stable—Sliding Balanced Position, Rotationally Unstable—Sliding Unbalanced Position, and Rotationally Unstable—Sliding Balanced Position where the contact areas of the sliding person and the surface are magnified.

[0033] When one of the contact surfaces is curvilinear, such as an ice skate, the angle α_{new} must not only take into account the frictional force, but also the rotation of the skate that is necessary to eliminate the torque caused by the misalignment of the Reaction Force from the $Line_{CoG}$, as shown in the FIG. **5** Rotationally Unstable—Sliding Unbalanced Position. Because the curvilinear contact surface will need to adjust to align the Reaction Force with the $Line_{CoG}$, it will need to further rotate an angle of β. Therefore the $\alpha_{new}=\alpha-2\beta$ (FIG. **6** Rotationally Unstable Sliding Balanced Position), which takes into account the angle necessary to address friction and instability.

[0034] The following conclusions are made.

Conclusion 1

[0035] To maintain efficient rotational balance in a sliding sport, that $Line_{CoG}$ needs to adjust from a balanced standing position (a vertical line) to a balanced sliding position by a specific angle.

Conclusion 2

[0036] For a sliding sport in which the sliding contact area is straight in the xy plane or has at least two contact points that are on the xy plane (for example roller skates), the angle of that $Line_{CoG}$ is equal to the inverse tangent of the coefficient of friction between the contact materials.

Conclusion 3

[0037] For a sliding sport in which the sliding contact area is curved (for example ice skates), the angle of $Line_{CoG}$ is equal to twice the inverse tangent of the coefficient of friction between the contact materials.

Conclusion 4

[0038] For a sliding sport in which the sliding contact area is straight, a lift, in either under the heel or under the ball of the foot to attain the specific angle, is approximately or essentially equal to the distance between the heel and the ball of the foot multiplied by the sum of the coefficient of friction between the contact materials and the angle "α".

Conclusion 5

[0039] For a sliding sport in which the sliding contact area is curved, a lift, in either under the heel or under the ball of the foot to attain the specific angle, is approximately or essentially equal to the distance between the heel and the ball of the foot multiplied by the twice the sum of the coefficient of friction between the contact materials and the angle "α".

Conclusion 6

[0040] By measuring the friction, either directly through a friction measuring device (such as a tribometer) or indirectly by measuring a dependent variable (for example temperature, contact area, etc.), a definite foot plane angle or size lift, for either under the heel or under the ball of the foot, for sliding person's stability can be attained.

Conclusion 7

[0041] Any imbalance in a sliding person, caused by a change in friction, can be corrected by using shims or changing the angle of the foot plane by a specified amount as calculated by Conclusions 3 through 6.

[0042] When there is a change in conditions, namely a change in the surface contact friction, a new foot plane angle may be determined using formulas in the following manner.

[0043] 1) Determine initial conditions of: contact surface friction (either directly from a tribometer or by determination from dependent variables, e.g. temperature, geometry, etc.), sliding person's weight, and efficient balanced posture (non-sliding).

[0044] 2) Adjust the foot plane angle by methods of Conclusions 1) through 6) or otherwise until gliding position is stable

[0045] 3) When sliding surface conditions change, adjust foot plane angle for:

[0046] i. a stable sliding contact surface in the plane of motion by the angle calculated by $\tan^{-1}(\mu_{initial})-\tan^{-1}(\mu_{changed})$ where μ is the contact friction OR

[0047] ii. an unstable sliding contact surface in the plane of motion by the angle calculated by $2\times[\tan^{-1}(\mu_{initial})-\tan^{-1}(\mu_{changed})]$

[0048] OR

[0049] When sliding surface conditions change, add heel or ball of the foot shims:

[0050] i) a stable sliding contact surface in the plane of motion by the amount calculated by $L\tan[\tan^{-1}(\mu_{initial})-\tan^{-1}(\mu_{changed})]$ where L is the heel to ball of the foot length OR

[0051] ii) an unstable sliding contact surface in the plane of motion by the amount calculated by $L\tan\{2\times[\tan^{-1}(\mu_{initial})-\tan^{-1}(\mu_{changed})]\}$

[0052] The above four formulas may be stated in words as follows:

(a) The inverse tangent of the initial friction coefficient minus the inverse tangent of the new friction coefficient;

(b) Two times the difference between the inverse tangent of the initial friction coefficient and the inverse tangent of the new friction coefficient;

(c) The heel to ball of the foot length times the tangent of the difference between the inverse tangent of the initial friction coefficient and the inverse tangent of the new friction coefficient;

(d) The heel to ball of the foot length times the tangent of 2 times the difference between the inverse tangent of the initial coefficient and the inverse tangent of the new friction coefficient.

[0053] As is apparent steps 1) and 2) above relate to establishing the initial or original foot plane angle which gives the person the best position for the initial friction coefficient. When there has been a change in friction coefficient, such as from being in a different location or changed conditions (e.g. temperature) in the same location, step 3) is used for determining the new foot plane angle.

[0054] In general, all ice skates, because of the rocker will have the same slope on a friction vs. foot plane angle graph. Skis and roller skates will have a different slope.

[0055] Subjectively an average person can feel a change of 0.2 mm lift, which equates to approximately a 0.0644 degree (64.4×10^{-3} degrees) change which is a change in friction coefficient of 0.56×10^{-3} (i.e. 0.0644 divided by −115).

[0056] The invention provides for the determination of the foot plane angle given the friction. The invention also provides practical guidelines for determining what change should be made to obtain a new foot plane angle where there has been a change in friction coefficient. FIGS. **7-11** are graphs correlating changes in friction coefficient with change in foot plane angle for different activities. The graphs are accurately to scale for purposes of this invention. In general when there has been an increase in friction coefficient, there will be a decrease in foot plane angle as determined by the appropriate graph. Conversely, when there has been a decrease in friction coefficient, the foot plane angle will increase by the corresponding amount on the graph. The change in foot plane angle can be achieved by use of shims in the boot at the heel or at ball of the foot. Thus, for example, when it is intended to increase the angle, a shim would raise the heel.

[0057] FIGS. **7-11** are graphs for specific activities. In each graph, the numbers along the horizontal axis, as stated at the bottom of the vertical axis, are the changes in friction coefficient. In practice the initial friction coefficient and the new friction coefficient would be determined and their difference would be a value on the horizontal axis. The change needed for the new foot plane angle would be the corresponding amount on the vertical axis at the corresponding point on the appropriate line in the graph for the particular activity. The same procedure would be repeated when there is a later further change in conditions wherein the prior friction coefficient would be considered as the initial friction coefficient.

[0058] FIG. **7** is a graph for a hockey skate and is referred to as The Hockey Skate Graph.

[0059] For all intents and purposes, between the friction coefficient values found in hockey skating, the curve is a straight line with a slope of approximately −115 degrees. In other words a positive change in the coefficient of friction of 1 would yield a negative change of 115 degrees in the foot plane angle (i.e. by raising the ball-of-foot lift and/or lowering the heel lift, or any other means of changing the angle).

[0060] Thus, in The Hockey Skate Graph the friction coefficient ranges would be from 0.00677 to 0.01488 (another way of expressing these values is in scientific form, i.e. 6.77×10^{-3} to 14.88×10^{-3}). The corresponding angle change would be less than 1 degree.

[0061] FIG. **8** is a graph for speed skating skates and is referred to as The Speed Skating Graph. It is noted that values on the horizontal axis, for convenience, are referred to by their exponential value. Thus, for example, 5.00 E-03 refers to 0.005 since E-03 means three decimal points. Similarly, 1.00 E-02 refers to 0.01, since E-02 refers to two decimal points.

[0062] For all intents and purposes, between the friction coefficient values found in speed skating, this curve is a straight line with a slope of approximately −115 degrees. In other words a positive change in the coefficient of friction of 1 would yield a negative change of 115 degrees in the foot plane angle (i.e. by raising the ball of foot lift and/or lowering the heel lift, or any other means of changing the angle).

[0063] Thus, the friction coefficient ranges in The Speed Skating Graph would be from 0.00282 to 0.01008 (another way of expressing these values is in scientific form, i.e. 2.82×10^{-3} to 10.08×10^{-3}). The corresponding change in the foot plane angle would be no greater than 0.8 degrees.

[0064] FIG. **9** is a graph for figure skating skates and is referred to as The Figure Skating Graph.

[0065] For all intents and purposes, between the friction coefficient values found in figure skating, this curve is a straight line with a slope of approximately −115 degrees. In other words a positive change in the coefficient of friction of 1 would yield a negative change of 115 degrees in the foot plane angle (i.e. by raising the ball of foot lift and/or lowering the heel lift, or any other means of changing the angle).

[0066] Thus, the friction coefficient ranges in The Figure Skating Graph would be from 0.01373 to 0.04070 (another way of expressing these values is in scientific form, i.e. 13.73×10^{-3} to 40.70×10^{-3}). The corresponding change in foot plane angle would be less than 2.5 degrees.

[0067] FIG. **10** is a graph for roller skating skates and is referred to as The Roller Skating Graph. For purposes of this invention, the rolling resistance coefficient which is applicable to roller skates, is treated as friction coefficient.

[0068] For all intents and purposes, between the rolling resistance coefficient values found in in-line roller skating, this curve is a straight line with a slope of approximately −57 degrees. In other words a positive change in the coefficient of friction of 1 would yield a negative change of 57 degrees in the foot plane angle (i.e. by raising the ball of foot lift and/or lowering the heel lift, or any other means of changing the angle).

[0069] Thus, the friction coefficient ranges in The Roller Skating Graph would be from 0.04 to 0.075 (another way of expressing these values is in scientific form, i.e. 40×10^{-3} to 75×10^{-3}). The corresponding change in foot plane angle is no greater than 2 degrees and more specifically is between 1 and 2 degrees.

[0070] FIG. **11** is a graph for Nordic Skis and is referred to as The Ski Graph.

[0071] For all intents and purposes, between the friction coefficient values found in Nordic skiing, this curve is a straight line with a slope of approximately −57 degrees. In other words a positive change in the coefficient of friction of 1 would yield a negative change of 57 degrees in the foot plane angle (i.e. by raising the ball of foot lift and/or lowering the heel lift, or any other means of changing the angle).

[0072] Thus, the friction coefficient ranges in The Ski Graph would be from 0.02 to 0.06 (another way of expressing these values is in scientific form, i.e. 20×10^{-3} to 60×10^{-3}). The corresponding change in foot plane angle is less than 2.5 degrees.

[0073] The present invention is thus based upon taking into account that there should be a change in foot plane angle when there is a change in friction coefficient in a sliding activity, such as ice skating, roller skating and skiing.

[0074] When the change in friction coefficient is determined, an appropriate change in foot plane angle can be made.

What is claimed is:

1. In a method of selecting the angle of a foot plane of a foot in the boot used in a sliding activity wherein the foot plane is originally at an original angle for a surface having an initial friction coefficient, the improvement being in changing the foot plane angle when the friction coefficient between the boot contact edge/surface and the surface of the sliding activity changes, comprising the steps of determining the initial friction coefficient, later measuring a new friction coefficient for the surface of a sliding activity, decreasing the foot plane angle from the original angle to a new angle when the friction coefficient increases, and increasing the foot plane angle to a new angle when the friction coefficient decreases.

2. The method of claim **1** wherein the new foot plane angle is obtained by the use of a shim inserted in the boot at the heel or at the ball of the foot.

3. The method of claim **1** wherein the boot is a hockey skate boot, and when the friction coefficient changes in the range of 0.00677 to 0.01488 the foot plane angle is changed by an angle in the range of less than 1 degree.

4. The method of claim **1** wherein the boot is a hockey skate boot and the foot plane angle is changed in accordance with the change in friction coefficient on The Hockey Skate Graph.

5. The method of claim **1** wherein the boot is a speed skating boot, and when the friction coefficient changes in the range of 0.00282 to 0.01008 the foot plane angle is changed in a range no greater than 0.8 degrees.

6. The method of claim **1** wherein the boot is a speed skating boot and the foot plane angle is changed an amount based on the friction coefficient change in The Speed Skating Graph.

7. The method of claim **1** wherein the boot is a figure skating boot and when the friction coefficient changes in the range of 0.01373 to 0.04070 the foot plane angle is changed in a range of less than 2.5 degrees.

8. The method of claim **1** wherein the boot is a figure skating boot and the foot plane angle is changed by an amount corresponding to the friction coefficient change in The Figure Skating Graph.

9. The method of claim **1** wherein the boot is a roller skating boot and when the friction coefficient changes in a range of from 0.04 to 0.075 the foot plane angle changes in a range no greater than 2 degrees.

10. The method of claim **1** wherein the boot is a roller skating boot and the foot plane angle changes by an amount corresponding to the change in friction coefficient in The Roller Skating Graph.

11. The method of claim **2** wherein the boot is a ski boot and when the friction coefficient changes in the range of from 0.02 to 0.06 the foot plane angle changes in a range of less than 2.5 degrees.

12. The method of claim **1** wherein the boot is a ski boot and the foot plane angle is changed by an amount corresponding to the change in friction coefficient in The Ski Graph.

13. The method of claim **1** wherein a tribometer is used to measure the friction coefficient.

14. The method of claim **1** wherein friction is determined based on temperature measurement.

15. The method of claim **1** wherein the foot plane angle is selected to maintain a reaction force at the surface of the sliding activity aligned with the center of gravity line of the person in the sliding activity.

16. The method of claim **1** wherein the foot plane angle change for a stable sliding contact surface is calculated by the inverse tangent of the initial friction coefficient minus the inverse tangent of the new friction coefficient and for an unstable sliding contact surface the foot plane angle is calculated by 2 times the difference between the inverse tangent of the initial friction coefficient and the inverse tangent of the new friction coefficient.

17. The method of claim **1** wherein the foot plane angle is changed by the addition of a shim to the heel or to the ball of the foot wherein for a stable sliding contact surface the angle is calculated by the heel to the ball of the foot length times the tangent of the difference between the inverse tangent of the initial friction coefficient and the inverse tangent of the new friction coefficient, and for an unstable sliding contact surface the foot plane angle is calculated by the heel to the ball of foot length times the tangent of 2 times the difference between the inverse tangent of the initial friction coefficient and the inverse tangent of the new friction coefficient.

18. The method of claim **1** wherein the method is repeated when there is a subsequent change in friction coefficient whereby the previous new friction coefficient is treated as the initial friction coefficient and the previous new foot plane angle is treated as the original foot plane angle.

19. A method of selecting the angle of a foot plane of a foot in the boot used in a sliding activity comprising of obtaining a balanced sliding position by measuring the coefficient of friction between the boot contact edge/surface and the surface of the sliding activity, and using the coefficient of friction to determine the foot plane angle by a technique selected from the group consisting of:

a) for a sliding sport in which the sliding contact area is straight in the xy plane or has at least two contact points that are on the xy plane, the angle of foot plane is equal to the inverse tangent of the sum of the coefficient of friction between the contact materials and the foot-plane angle relative to the horizontal, when the length of the conceptual line from the center of gravity to the ball of the foot (where the conceptual bisect lines through the angles formed between the connecting body parts torso, upper leg, lower leg and foot are perpendicular to that line) is at a minimum and when the person is the non-sliding balanced position wearing his/her activity-specific footwear;

b) for a sliding sport in which the sliding contact area is curved, the angle of the foot-plane is equal to twice the inverse tangent of the sum of the coefficient of friction between the contact materials and the foot-plane angle relative to the horizontal, when the length of the conceptual line from the center of gravity to the ball of the foot (where the conceptual bisect lines through the angles formed between the connecting body parts torso, upper leg, lower leg and foot are perpendicular to that line) is at a minimum and when the person is the non-sliding balanced position wearing his/her activity-specific footwear,

c) for a sliding sport in which the sliding contact area is straight, a lift, in either under the heel or under the ball of the foot to attain the angle, is generally equal to the distance between the heel and the ball of the foot multiplied by the sum of the coefficient of friction between the contact materials and the foot-plane angle relative to the horizontal, when the length of the conceptual line from the center of gravity to the ball of the foot (where the conceptual bisect lines through the angles formed between the connecting body parts torso, upper leg, lower leg and foot are perpendicular to that line) is at a minimum and when the person is the non-sliding balanced position wearing his/her activity-specific footwear; and

d) for a sliding sport in which the sliding contact area is curved, a lift, in either under the heel or under the ball of the foot to attain the angle, is generally equal to the distance between the heel and the ball of the foot multiplied by the twice the sum of the coefficient of friction between the contact materials and the foot-plane angle relative to the horizontal, when the length of the conceptual line from the center of gravity to the ball of the foot (where the conceptual bisect lines through the angles formed between the connecting body parts torso, upper leg, lower leg and foot are perpendicular to that line) is at a minimum and when the person is the non-sliding balanced position wearing his/her activity-specific footwear.

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