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Notes on Applied Anatomy

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Mechanics of Balance

Balance on one foot

How does the ballet dancer balance on one foot?

In looking at the photo at right, your answer might be: "Simply. Easily. Naturally." Like all experts, she makes the difficult look easy.

But as you will know if you try it, it is not easy. A lot of training has gone into being able to hold that pose. Some of a dancer's skill develops through persistent repetition from an early age. This is needed.

But there is also a body of knowledge that can accelerate the learning process -- at any age. It has to do with the coordination of body parts around axes of rotation. When that clarifies, mentally, then, physically, also, action clarifies.

One-word vs. two-word descriptors

Describe, if you will please, how the woman at right has moved her shoulder.

Probably you will say, "She has moved it forward."

This is a true description, and economical. But it is incomplete. It would be more accurate to say, "She has moved her shoulder forward and leftward." Or "forward and inward."

And what about her other shoulder? Usually people say, "She has moved the left shoulder backward."

But it is more complete to say that she has moved it backward and rightward. Or backward and inward.

The one-word descriptions are conveniently short. But they are inaccurate because they describe movement along one dimension, which means on a line. The two-word description is more complete because it describes movement along two dimensions, which means a plane. It talks about an arc, which is part of a circle.

You could make the description even richer by observing that she also moves the right shoulder down. This takes the discussion into three dimensions. It is a very interesting expansion of the topic! But for now we will stick with two.

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"Not a line! An arc!"

The differentiation between a linear or circular understanding of movement became important to me in one instant, years ago, when I was working with a client, Madeline, who had shoulder pain. She was lying on her left side on my table, and I was sitting on a stool at her head just as in the photo at right. I had placed my hands on her right shoulder, and I was asking through my hands, "What will it be like for this shoulder to go 'some up' or 'some down'?"

In response to my question, the shoulder didn't move up. It didn't move down. It didn't do anything at all.

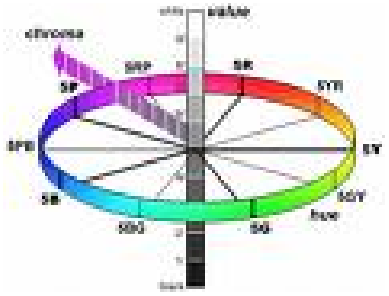
I found this unsettling. Why not? How can a shoulder not move?

Then -- with a flash of insight -- a new thought came to me: "When a shoulder moves from this starting position, it moves 'some up and in' and then 'some down and in'." When I tried next to move her shoulder with this idea of an arc, it just floated. There was no problem at all. It was as though it had been greased. Madeline and I were both so happy.

After that, every day I saw another application where, following the association given by one-word descriptors, I had an inner representation of linear movement. This was incorrect, and the more correct understanding was that the movement was circular.

An arc, a whole circle, a center, and an axis

In subsequent days I understood more details.



Every time you have an arc you also have three other elements:
1) a whole circle to which the arc belongs
2) a center of that circle and
3) an axis around which the circle revolves.

The drawing at right gives an example of a circle around the vertical axis.

As we live in a three-dimensional world, there are three axes of rotation.

The vertical axis

The most common axis in human movement is the vertical. Partial movements around this axis are usually called 'turning', and we do them all the time. Twists are also movements around the vertical axis -- the upper body turns one way and the lower the other. The woman a few paragraphs ago who was standing "with her right shoulder forward" was using this axis to rotate her shoulders and torso. This is the same axis that is used in dance to do a pirouette, and in figure skating, a spin.

The horizontal axis

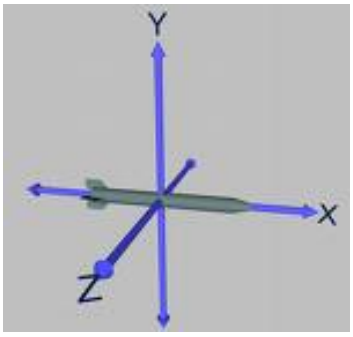
The second most common axis of rotation is the horizontal. All the bending movements use this one. In the photo at right the woman is bending in the hip joint. Note that in relation to the usual upright standing position, her head has come down and forward.

The sagittal axis

The least common is the front-to-back axis. It is so rarely discussed that there isn't even an everyday word for it. The anatomist's word is sagittal, or anterior-posterior. The easiest example is the gymnast's cartwheel.

These three axes of rotation are the building blocks of all movements. You can do simple movements using predominantly one axis. More complex movements use combinations of them.

The language of math



Say you want to describe how a person moves in terms of the fundamental axis of rotation. Let's imagine Susan who is standing. She turns to the left. To describe her movement you say, "She is turning around the vertical axis." This is a true and simple statement.

But what happens when Susan lies down on her back, bends her knees and places her feet on the floor, crosses her arms over her chest, hugging herself, and rolls in a happy manner from side to side. What axis is that? You could say, as I sometimes do when teaching, "Susan is rolling around the axis that is 'vertical-when-standing'." This works! But it lacks elegance.

A more elegant choice is to use the language of math. In math the vertical axis is called Y. "Y" is just a name. So now you can use fewer words and say, "Susan is taking a Y axis movement, at one moment while standing and at another while lying down."

If you'll make the effort to get used to this vocabulary, you will find that it simplifies things later on.

Movements around the Y axis

One example of the usefulness of this vocabulary is in describing a swimmer's action. Good technique requires that the swimmer rotate his body as he lies in the water. This helps him to turn his head to get a breath and raise his arm out of the water, among other things. It is a Y rotation, not while standing.

Movements around the X axis

The movements that are called "bending" are X axis rotations. Other commons words include: "arching, rounding, flexion, extension and folding."

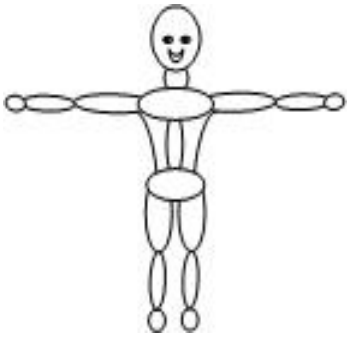
The man at right is bending in his ankles, knees and hip joints preparatory to leaping onto the box. His back and head are also arched. His elbows are lightly flexed. These are all X axis rotations in the relevant joints.

Movements around the Z axis

When you tilt your head to the side to hold the phone to your ear, that is a Z axis movement of the head. If you don't use a hand to hold the phone, but instead hold it by pressing the shoulder to the head, then you have two counterbalancing Z axis movements:

1) the head rotating clockwise and
2) the shoulder and related ribs rotating counterclockwise.

Balancing on one foot

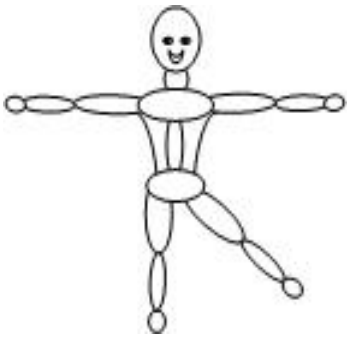


So now we have enough background to discuss the question: "How does a dancer balance on one foot?"

Let's begin in a simple, balanced pose on two feet.

You have the intention next to stand only on your right foot.

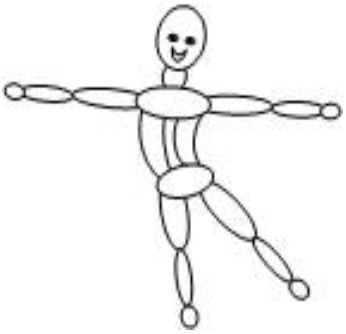
Raising one leg as an isolation



Do you keep everything constant and just raise the left leg to the side?

When you look at the drawing at right, you can see how stiff the move looks. *Ignore, please, the fakey smile*. It is not at all natural or balanced. You would have to have very powerful muscles to hold everything in place and just raise one leg straight to the side.

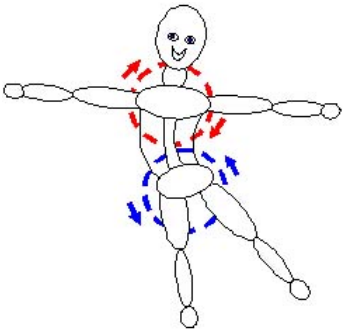
Using the torso



What really happens is that you use the torso to help raise the left leg. You bend in the spine. The bend makes several things happen at once:

1) the left hip comes higher *(becomes lighter)*
2) the right hip presses down *(becomes heavier)*
3) the left shoulder comes lower
4) the right shoulder goes higher
5) the left ribs compress
6) the right ribs bow out

Two Z axis circles rotate toward each other



These details can be summarized as the consequences of two circles, Z axis circles, rotating toward each other. The upper circle rotates clockwise and the lower counter clockwise.

The consequence of the dual rotation is that you get

1) longer on the weighted leg and
2) shorter on the unweighted leg.

When you work with yourself to clarify your ability to move like this, you will find that you are more secure in your balance.

More to see

Once you get used to this way of seeing, and take the initiative to observe other people's movement, you will see more and more examples of this pattern. For example, look at this field goal kicker.

Weighted side. His weight is on his left leg. The left ribs are bowed out. The left shoulder and arm are high.

Unweighted side. The right leg is in the air, unweighted. The right ribs are compressed. They draw the right hip up and the right shoulder down.

More effort than one sees

One thing that is interesting to me in the study of balance is the deeper awareness of how much effort it takes to stay on one foot.

The word "balance" doesn't immediately give that impression. I can easily get an association from it of "no effort."

But in this study of two rotating circles in counterbalancing movement, one can clearly perceive that it takes energy to be balanced on one foot. It may LOOK effortless, but it is not.

Art is illusion!

Another step more complicated

The focus so far has been on rotations in a single plane. But, of course, a dance gesture can easily be more complicated. For example, in this photo of Baryshnikov, one can easily see the Z axis contribution: the left side is compressed, bringing the left hand and left leg close to each other, while the right side is elongated with the right arm and right leg maximally distant.

In addition, Mikhail has strongly arched his back and let his head fall backwards. These are X axis movements. One can think again of two counterbalancing circles. Both are behind his back, one behind his upper body, and one behind his lower. They rotate, around the horizontal axis, inward -- toward each other. And he arches!

All three

And then, of course, a beautiful dance move can use all three axes. Here is Patrick Chan, Canada's figure skating champion. His weight is on one foot, the right; that takes good Z axis work. He is deeply bent in the right knee and ankle and in both hip joints; that is X axis folding. And he is rotated so he looks left; Y axis. Natural talent! Years of practice! And good body part mechanics!