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Study of the effect of table thickness on bounce height of a table tennis ball.

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Aim

The aim of this experimental study is to determine the minimum thickness of the top of a table tennis table so that it meets the International rules of play.

Table tennis tables that you can buy vary greatly in top thickness and price, it can be very difficult to know whether the bounce or rebound of the surface will be sufficient to meet the official rules. While this may not affect lower standard play, players wishing to play at home or others wishing to buy tables will want to ensure that the surface meets their needs.

Background

Table tennis table tops are generally made from wood and can be anywhere from 3 to 30mm thick. The international rules number 2.1.3 state 'The playing surface may be of any material and shall yield a uniform bounce of about 23cm when a standard ball is dropped on to it from a height of 30cm (300mm)."(ITTF Laws of the Game, 2012)

So the question is what is the minimum thickness to meet this requirement, and why is this important. A table that has a low bounce makes playing attack shots difficult and limits the style of play to less than what is intended.

Some experts (Letts, 2008, Skorlz, 1973) recommend a table of 19mm thickness minimum for competitive play and it is of interest to see if this is validated in this study.

There is likely to be prior testing and research by manufacturers of high end table tennis tables of this nature though nothing could be found on the internet or library sources. Only the recommendations of some expert players previously mentioned.

Hypothesis

It is believed that ball rebound height will increase with thickness of the surface up to a limit governed by the properties of the ball. At thicknesses above a certain level no measurable increase in rebound height is expected. The hypothesis is shown graphically below.

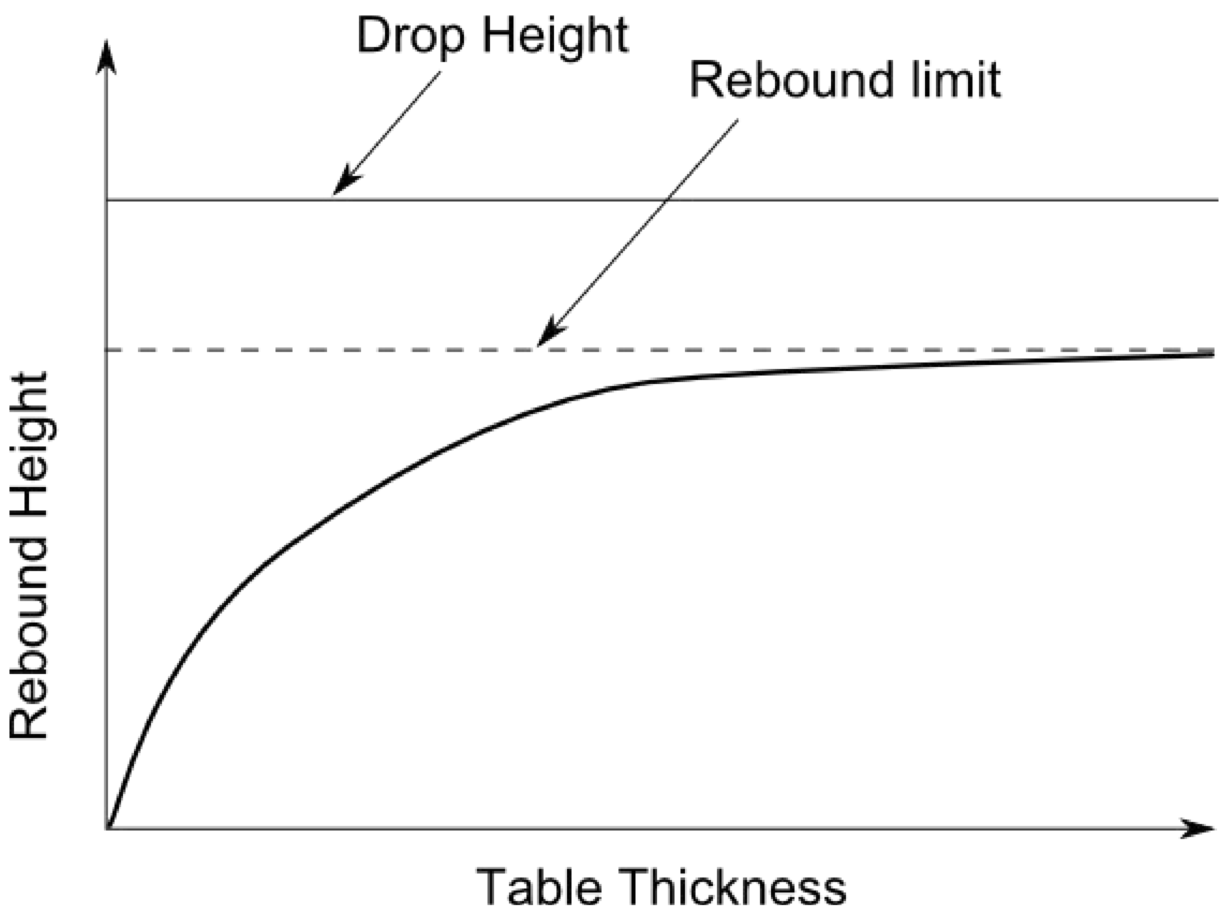

Figure 1.

Materials

Timber specimens measuring 350x80mm of various thickness,at least four thickness are to be tested, ranging from 3mm to 30mm thick.
A stand to hold background grid and hands free ball release holder.
2 x diameter 12mm steel rods to support specimens.
Video camera with tripod.
Well lit level area.
1 x 3 star diameter 40mm table tennis ball. Mass 2.8g
Spirit level.

Risk Assessment

Stand construction will use hand tools, saw, hammer, screw driver, file.
Care to be taken with tools to avoid cuts or impact injuries. Remove all sharp edges especially on steel rods. Seek adult help if in doubt.

Experimental Method

Step 1.

The specimens (timber boards of various thicknesses) are the be placed on the two 12mm diameter rods spaced 300mm apart on a firm level table. Use the spirit level to check and adjust as needed. As shown in Photo 1.

Step 2.

The stand comprising the background grid and ball holder/release mechanism is the be placed so the the ball shall land at about the mid point of the specimen and so that the ball drops from about 300mm above the specimens upper surface.

Step 3.

The video camera is placed at about 200mm above the specimen surface to reduce parallax errors.

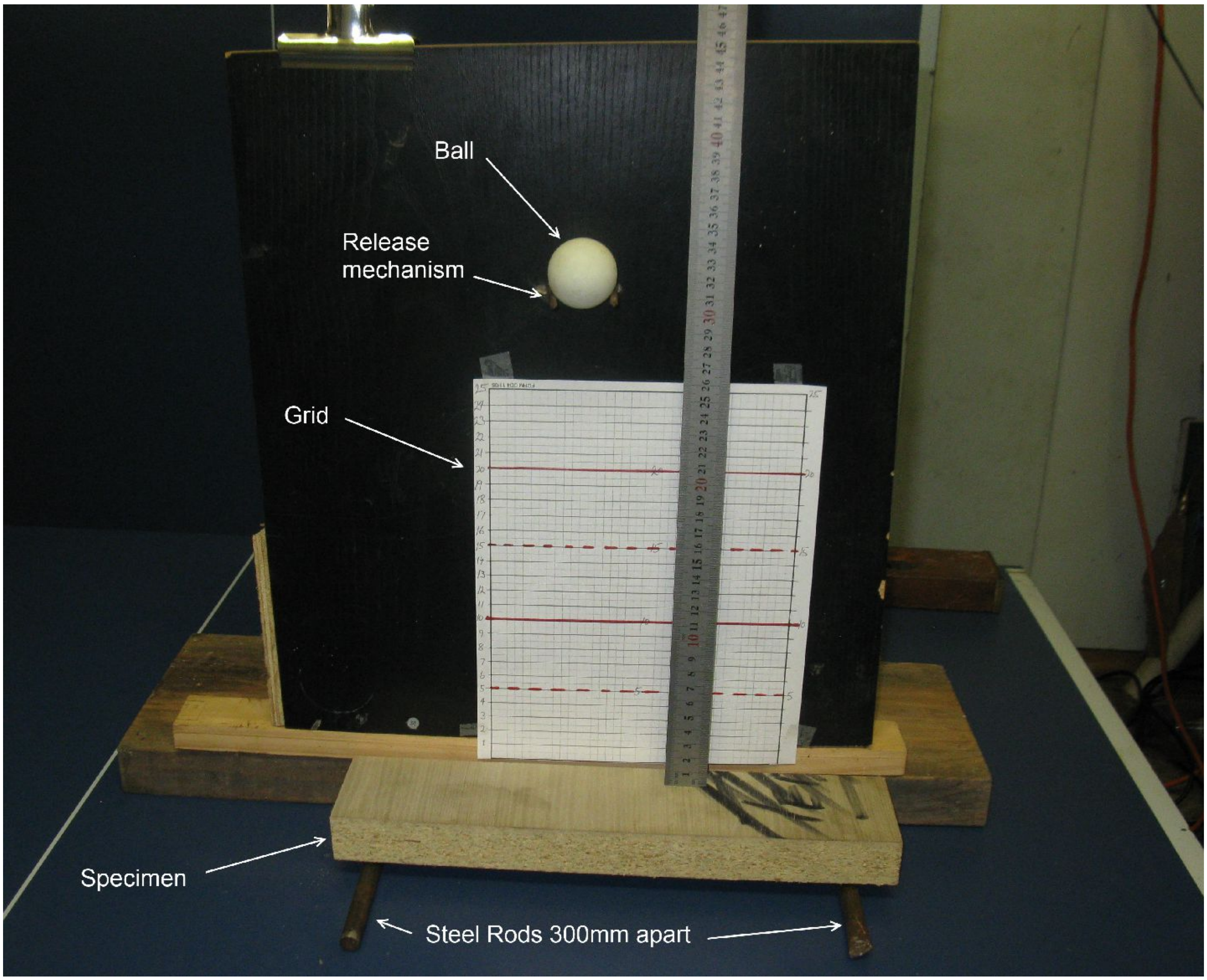

Photo 1. Experiment setup

Step 4.
The ball release mechanism is two 1/8" x 4" long nails pushed through two holes that have been slotted so the nails can rotate horizontally, at the back of the board the nails are squeezed quickly together which spreads them at the front and allows the ball to drop in a more consistent way.

Step 5.
The grid is graph paper background with 5mm squares and with horizontal lines in red marked every 50mm to 250 mm high is attached to the board so it's lower edge is level with the top of the board.

Step 6.
The camera used is a cannon digital camera in movie mode with a 30 frame per second recording rate at 640 x 480 pixels mounted on a small tripod. The camera is set to record for each set of drops for each specimen.

Results

Test #1. Specimen Thickness (mm)			34	
Drop	Drop height(mm)	Estimated Rebound Height(mm)	Rebound Height from Camera Footage(mm)	Rebound Calc'd for 300 mm Drop
1	305	280	235	231
2	305	230	230	226
3	305	240	232	228
4	305	240	230	226
5	305	240	237	233
Average	305	246	232.8	229.0

Table 1.

Test #2. Specimen Thickness (mm)			25	
Drop	Drop height(mm)	Estimated Rebound Height(mm)	Rebound Height from Camera Footage(mm)	Rebound Calc'd for 300 mm Drop
1	315	230	245	233
2	315	230	235	224
3	315	225	238	227
4	315	230	240	229
5	315	220	243	231
Average	315	227	240.2	228.8

Table 2.

Test #3. Specimen Thickness (mm)			16	
Drop	Drop height(mm)	Estimated Rebound Height(mm)	Rebound Height from Camera Footage(mm)	Rebound Calc'd for 300 mm Drop
1	303	200	220	218
2	303	200	226	224
3	303	200	221	219
4	303	210	225	223
5	303	210	226	224
Average	303	204	223.6	221.4

Table 3.

Test #4. Specimen Thickness (mm)			9	
Drop	**Drop height(mm)**	**Estimated Rebound Height(mm)**	**Rebound Height from Camera Footage(mm)**	**Rebound Calc'd for 300 mm Drop**
1	311	180	187	180
2	311	170	176	170
3	311	160	177	171
4	311	160	178	172
5	311	170	185	178
Average	311	168	180.6	174.2

Table 4.

Test #5. Specimen Thickness (mm)			3	
Drop	**Drop height(mm)**	**Estimated Rebound Height(mm)**	**Rebound Height from Camera Footage(mm)**	**Rebound Calc'd for 300 mm Drop**
1	298	60	70	70
2	298	50	70	70
3	298	50	72	72
4	298	40	66	66
5	298	50	70	70
Average	298	50	69.6	70.1

Table 5.

Note : Rebound calculated is based on the reasonable assumption that for drop heights close to 300mm that the rebound height will vary in proportion to the drop height. Thus if the ball is dropped from 330mm, 10% higher we can expect the rebound to be 10% higher than what is measured at 300mm. Conversely is we measure say 200mm rebound for a 330mm drop then for a 300mm drop we can calculate that the expected rebound for a 300mm on the same specimen would be 200 x300/330 = 181mm

So in our tables Rebound Calc'd = Rebound from Camera x 300 divided by Drop Height

Example Test 5 Drop 1 Rebound Calc'd = 187 x300/311 = 180 mm

Results Summary	
Thickness (mm)	**Rebound for 300mm Drop**
3	70.1
9	174.2
16	221.4
25	228.8
34	229.0

Table 6.

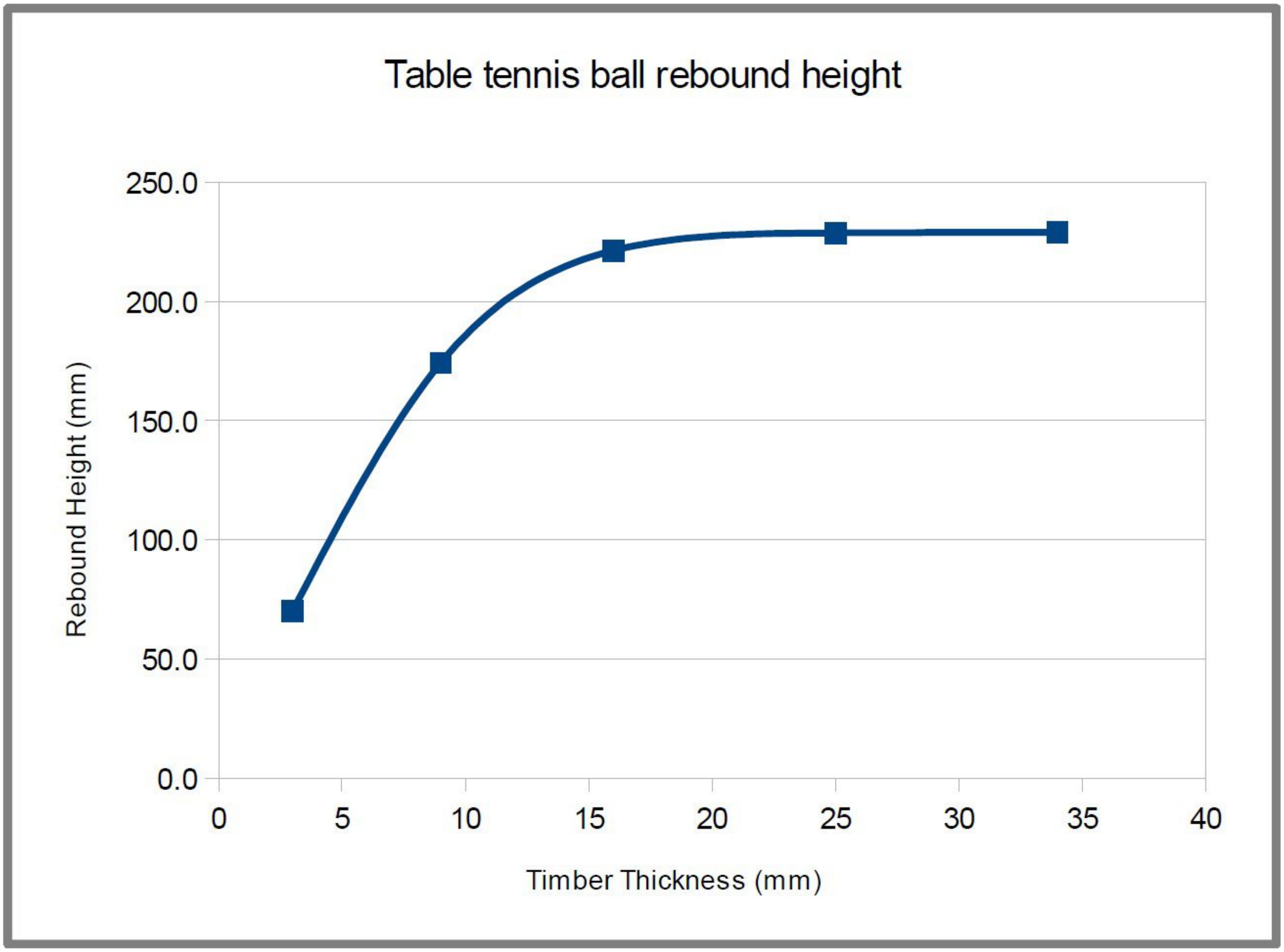

Figure 2. Results summary

Discussion & Error Analysis

The results shown a very good correlation to both our hypothesis and the experts opinion on minimum thickness for competitive play. As can also be seen by comparing figures 1. and 2. It was interesting that even with the 34 mm thick specimen the rebound height of 230mm (23cm) required by the international rules was still not achieved, it is suspected that the age of the ball used may have reduced it's rebound height, the height achieved was very close though at 229 mm and experimental errors could also have led to a reduction in the measured rebound.

Our independent variable was the thickness of the wood specimen our dependent variable was the height of rebound of the ball. It was attempted to keep the drop height of the ball constant, though this was challenging and instead chose to use a correcting formula as the variation in drop height was small. The wood used was all of the chipboard or manufactured type, not wood that was natural with a grain so that the specimen properties were fairly uniform. The release mechanism caused some variability, in that the start of free fall of the ball was slightly governed by how quickly the nails were squeezed together, the effect was only in the order of an estimated +/- 5 mm in drop height variation over 300mm so less than 10/300 = 3.3%.

Five drops for each specimen thickness were made to attempt to even out the effects of drop mechanism variation and other random effects, the results were then averaged and drop height corrected.

There were some difficulties with the ball release mechanism when not squeezed quick or evenly enough. The ball would drop at an angle and not land near the center of the specimen, when this occurred the drop was not recorded and was repeated.

When reviewing the camera video footage the top of the rebound image was sharp as the balls speed was zero at this point, a camera with a higher frame rate maybe 60 fps would have allowed greater accuracy in measuring the height. With the camera and grid used the measurement resolution was only about +/- 2mm but was sufficient to show our hypothesis correct and give some useful data.

It is theorized that the thicker board gave a higher rebound than the thinner board due to the thinner board deflecting during the ball impact which had the effect of absorbing a much larger amount of the balls kinetic energy, this energy being dissipated in the board as heat and noise. The board deflection was able to be seen on the video on the thinnest board. The thicker boards deflected almost not at all due to the relatively small impact force of the

low speed light table tennis ball. The energy loss at impact with the thicker board is being governed by energy losses related to the ball itself, it's surface will deflect slightly resulting in energy loss as heat and noise, and air resistance will also absorb some of the balls kinetic energy as it falls and rises, this loss is not greatly affected by the board thickness and thus this gives rise to the rebound limit hypothesized in figure 1.
If no energy was lost during the impact the ball would return closest to it's original drop height, although there would still be a loss of kinetic energy due to air resistance which is significant for the light table tennis ball. A superball is a good example of a ball that has a very low energy loss when impacting hard surfaces and it rebounds exceptionally.

Below are some stills from the video footage for the 34mm thick specimen. Which give an indication of the measurement resolution and drop mechanism function.

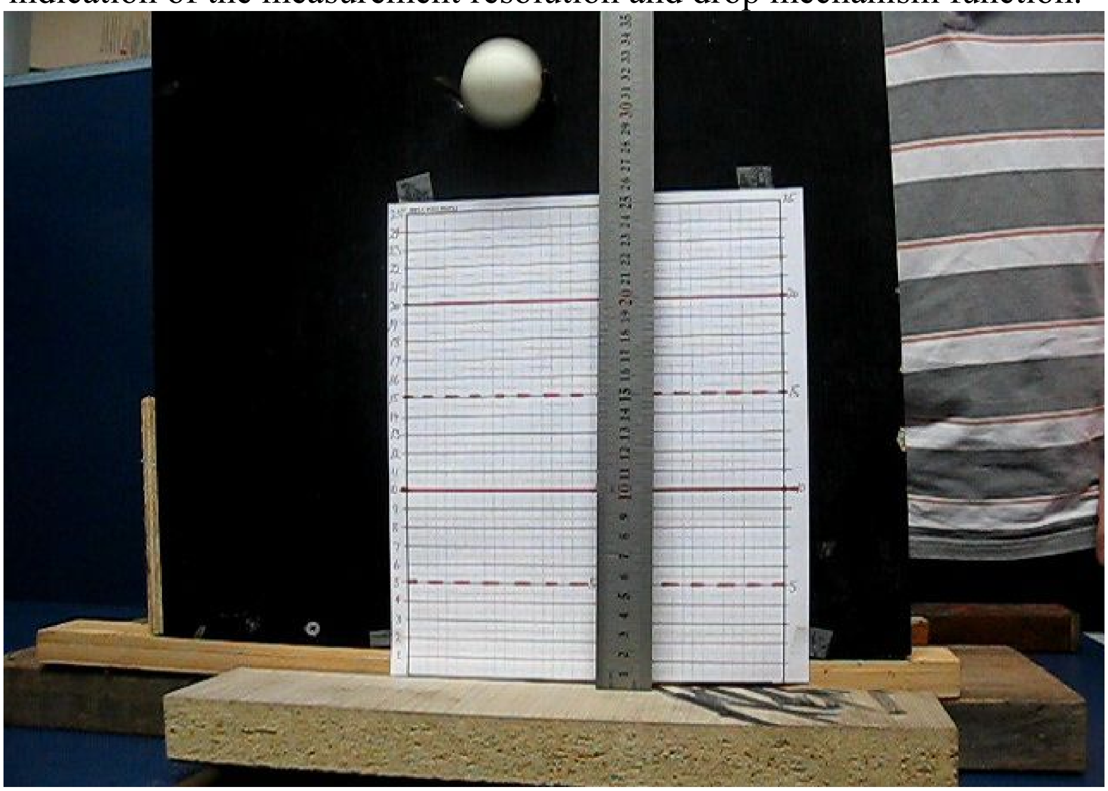

Photo 2. Ball image at drop release.

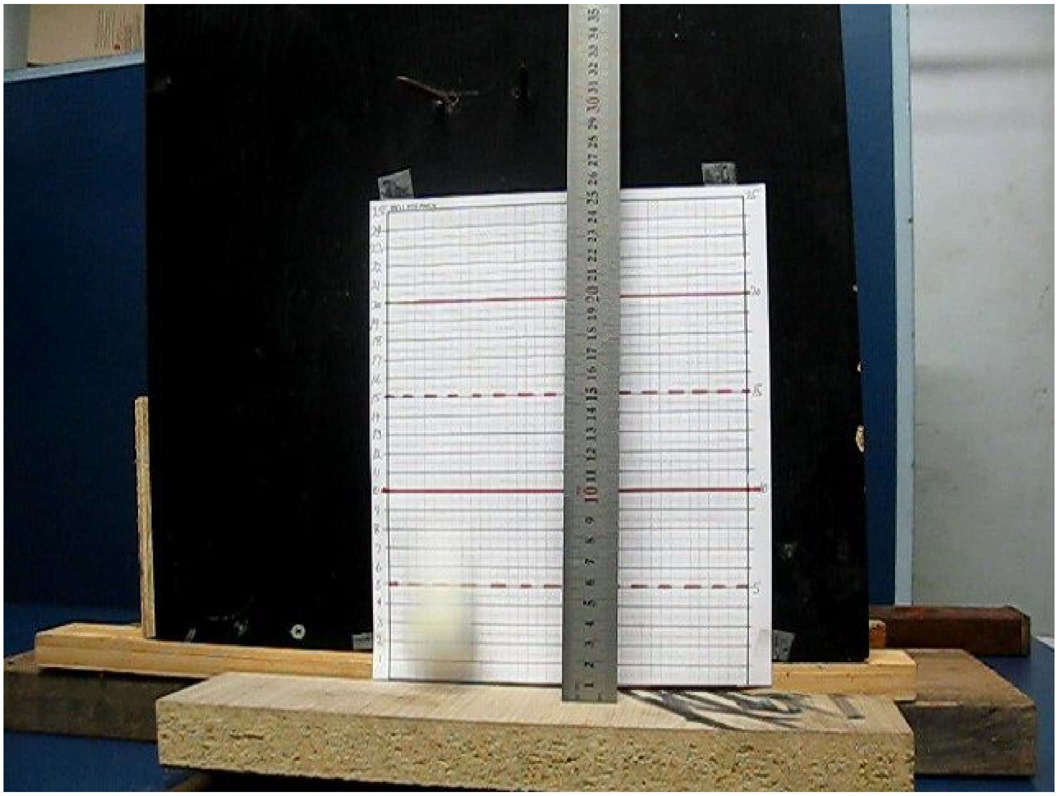

Photo 3. Ball at impact

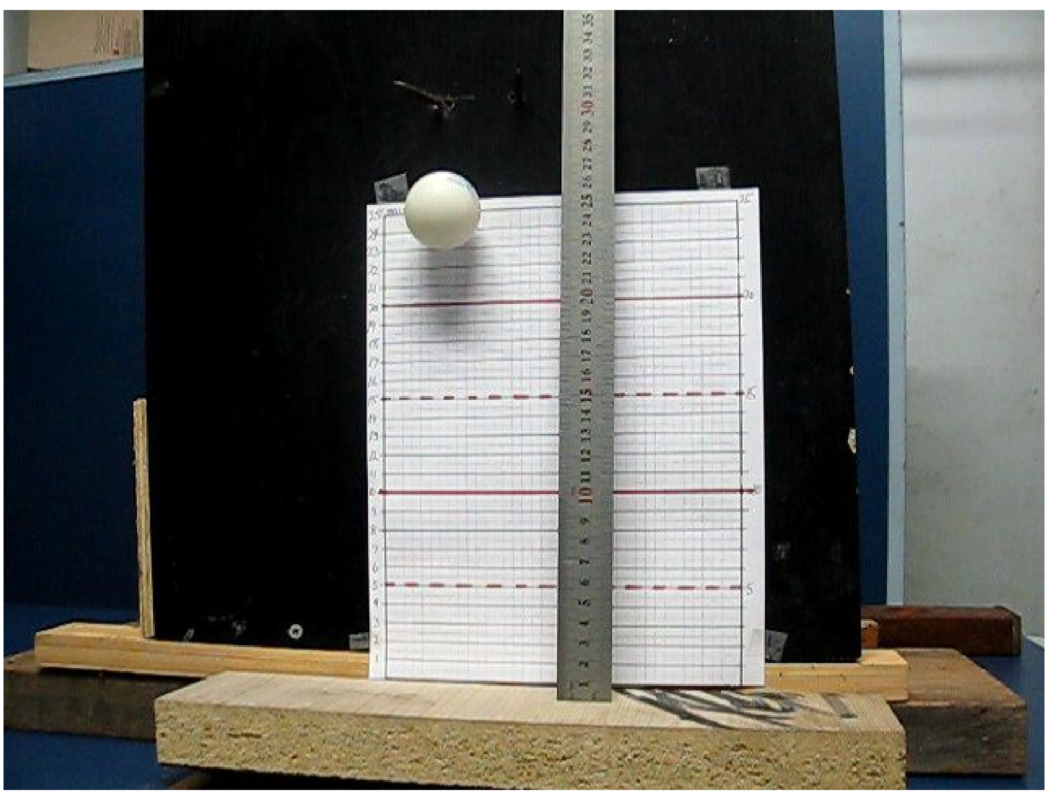

Photo 4. Ball drop at top of rebound (note clear image, showing stopped ball)

To improve accuracy a number of things could be done:
– use a higher speed, higher resolution camera
– used a finer grid background
– used a release mechanism that was not human reliant say air cylinder or electric powered
– use spacers between the steel rod to keep them an accurate distance apart
– use a back board that allowed the release height to be adjusted in fine increments rather than by using timber packers

Conclusion

The experiment did indeed show that ball rebound height increased with board thickness towards a limit very much as was hypothesised. It also seems that the recommendation of a 19mm thick surface for competitive play is a good one and should provide a bounce at or very close to the requirement of a 23cm rebound. The tests also show that surfaces below about 12mm should not be considered for anyone wish to play table tennis as it is intended.

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