The Mechanics of judo Ukemi

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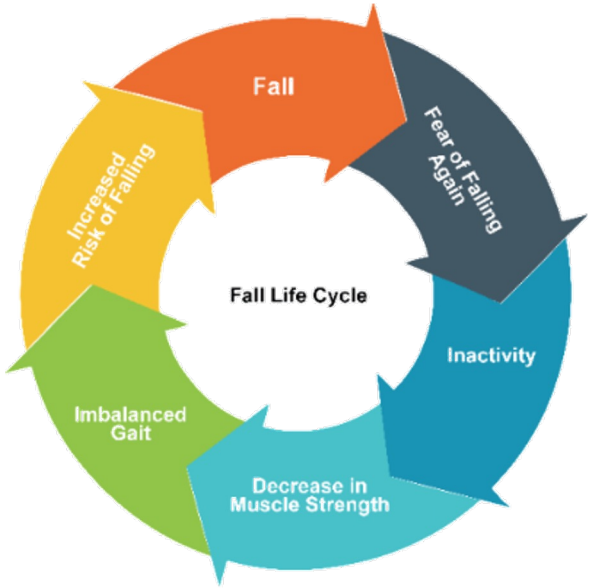
Overview 概要

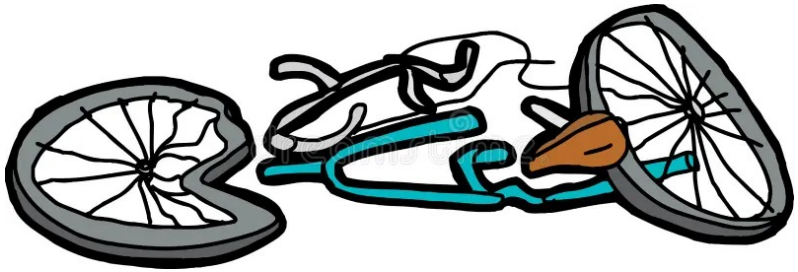
- Fear of Falling Cycle
- Why Biomechanics?
- Why Ukemi?
- Concepts

Fear of Falling cycle

- We know that practising ukemi leads to safer falls

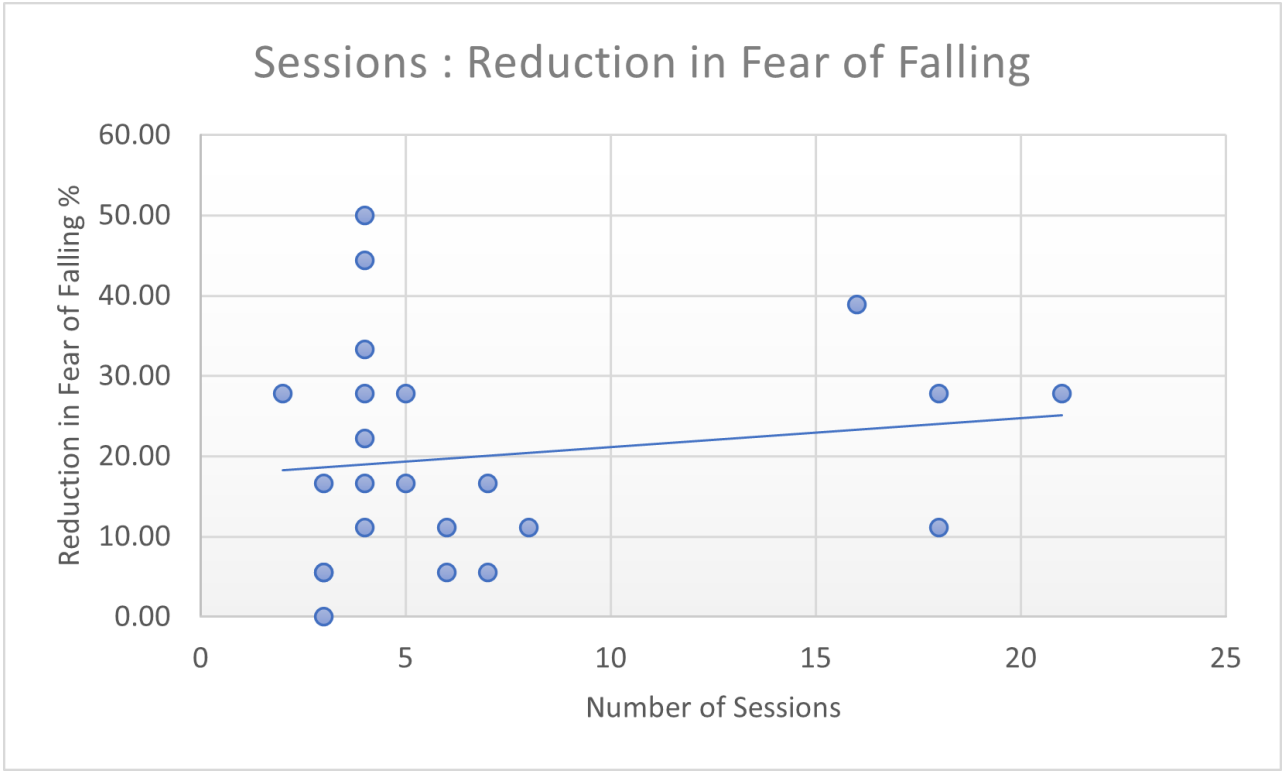
- And breaks the Fear of Falling cycle





Ukemi works!

- Mean Average Reduced FOF = 20.05%



But why do ukemi work?

- How can I **easily** explain them to older people?
- 高齢者にわかりやすく説明するにはどうすればいいでしょうか？
- How can I **scientifically** explain them to the medical profession?
- 医療従事者に科学的に説明するにはどうすればいいでしょうか？

Jigorō Kanō

The strength of a man standing in front of me is 10 units, whereas mine, is 7 units. As he pushes me with all his force I shall certainly be pushed back…

But if I were to give way by withdrawing my body, remembering to keep my balance, then he would naturally lean forward and thus lose his balance

私の前に立っている男の力は10単位だが、私の力は7単位だ。彼が全力で私を押したら、私は間違いなく押し戻されるだろう…

しかし、もし私がバランスを保ちながら体を引っ込めて譲ろうとすれば、彼は自然に前に傾き、バランスを崩してしまうだろう。

Gunji Koizumi

Judo relies on gravity, dynamics, and mechanics.

Analysing judo techniques involves understanding mechanical laws governing human body movement and function

柔道は重力、力学、そして力学に依存しています。

柔道の技を分析するには、人体の動きと機能を支配する力学的法則を理解する必要があります。

Ukemi techniques in judo

講道館
KODOKAN

- Identified by the Kodokan

1. *yoko-ukemi*
2. *ushiro-ukemi*
3. *mae-ukemi*
4. *mae-mawari-ukemi*

Yoko-ukemi

講 道 館
KODOKAN

- 4 Kodokan ukemi
- Yoko-ukemi for sideways falls
- Usually the cause of hip fractures
- Contact the tatami with:
  - Foot, leg, side body, arm and hand

Concepts

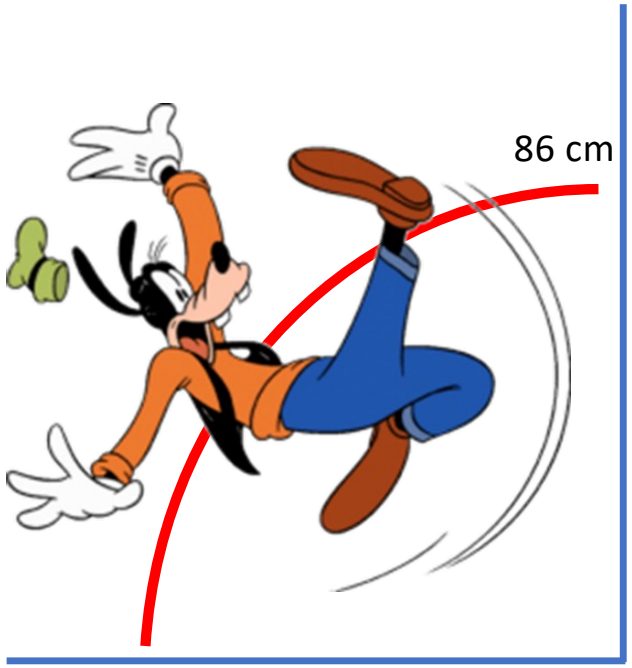
Fundamental Units	Kinematic Quantities	Balance Concepts	Newton's Laws
Mass	Velocity	Centre of Mass	1st Law
Distance	Acceleration	Equilibrium	2nd Law
Area	Momentum	*Kuzushi*	3rd Law
Time	Pressure		

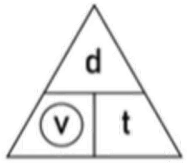
Concepts

Kinematic Quantities	Balance Concepts
Velocity	Centre of Mass
Acceleration	Equilibrium
Momentum	*Kuzushi*
Pressure	

Kinematic Quantities

Velocity

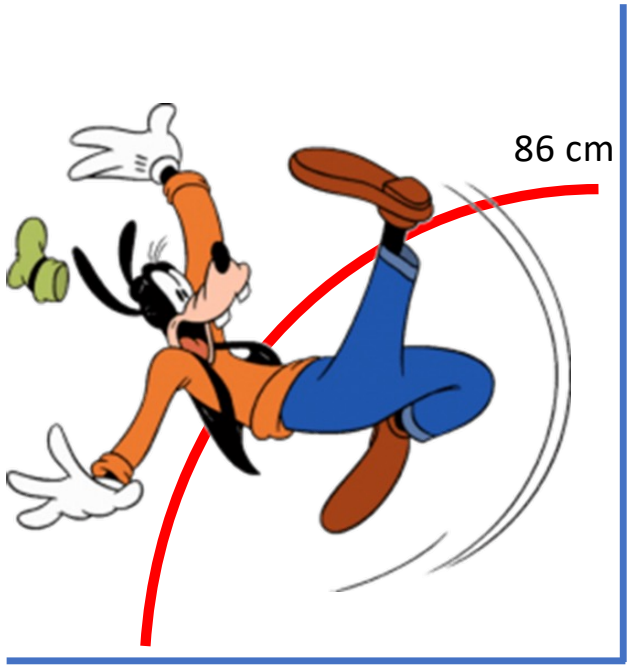


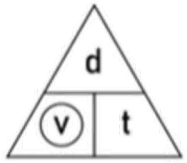


$v = d \div t$

- 70-year-old woman, average height = 1.6 m
- 70歳女性、平均身長1.6m
- Centre of Mass (54% of height) = 0.86 m
- 重心（身長の54%）= 0.86m
- Arc of fall distance travelled approx. 1.35 m
- 落下距離（円弧）約1.35m

Velocity

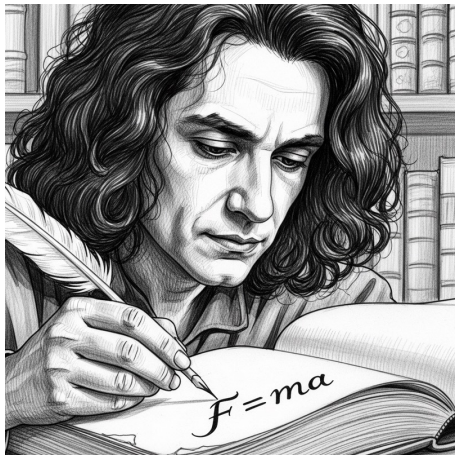




$v = d \div t$

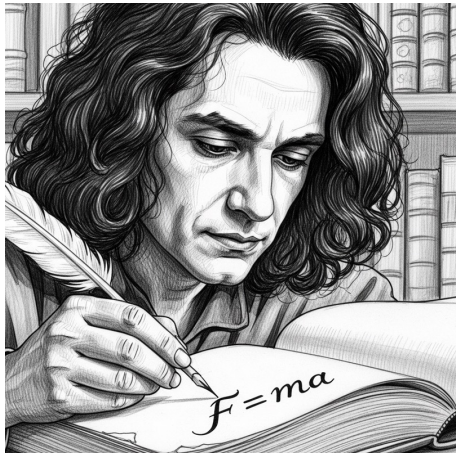
- Fall movement time $\bar{x}$ = 855 ms (range 539 ms - 1170 ms)
- 落下動作時間 $\bar{x}$ = 855ms（範囲 539ms～1170ms）
- Impact velocity of a fall = 1.35 m/0.855 s = 1.58 m/s
- 落下時の衝撃速度 = 1.35m/0.855s = 1.58m/s
- By bending knees, reduce CoM height, reduce distance and reduce impact velocity
- 膝を曲げることで、重心の高さ、距離、そして衝撃速度を低下させることができます。

Acceleration



- Newton’s Second Law
- ニュートンの第二法則
- **Force F=mass x acceleration**
- 力 F = 質量 × 加速度
- Standard value of gravitational acceleration on earth
- 地球上の重力加速度の標準値
- a = 9.80665 m/s^2

Acceleration



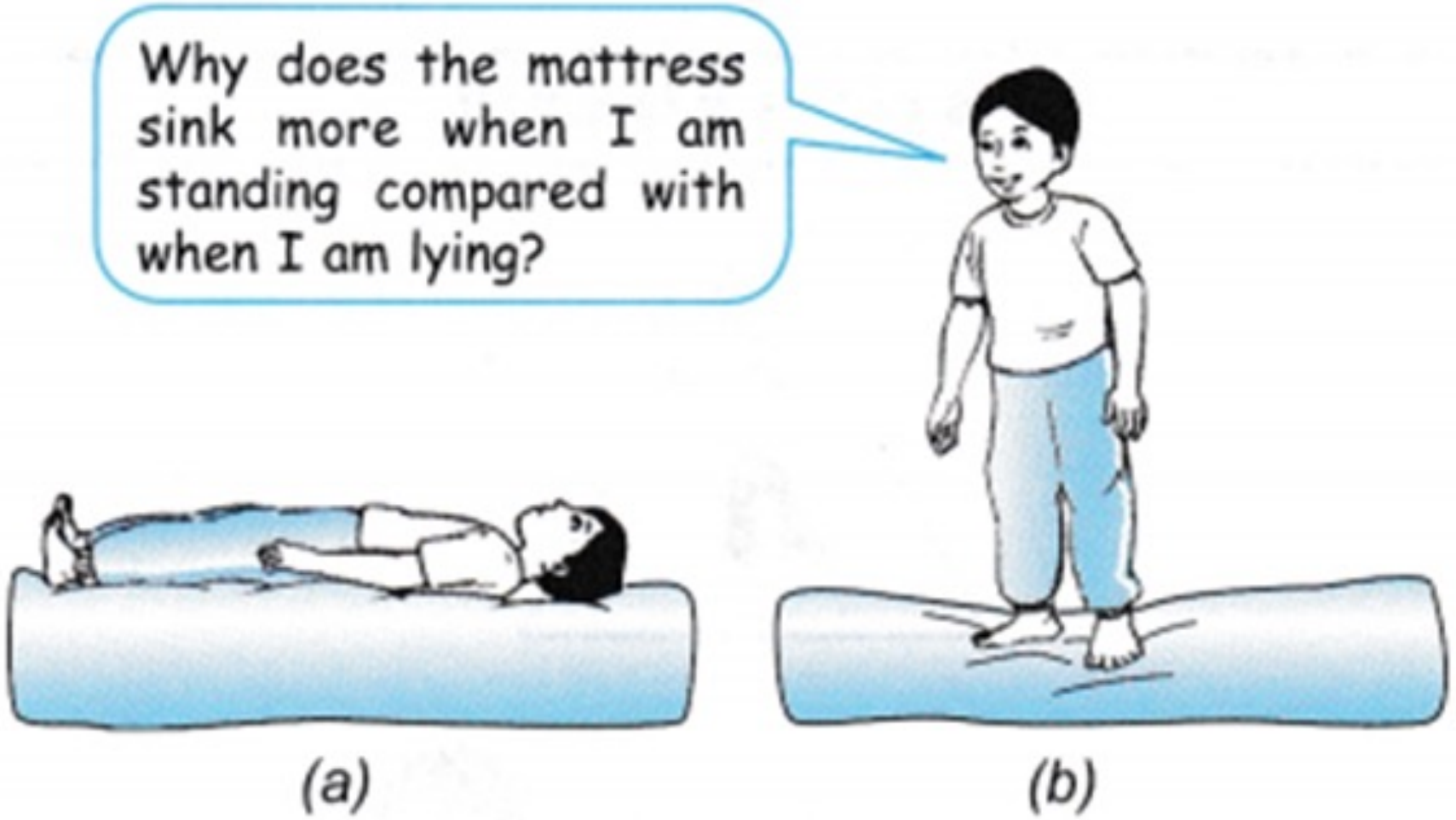
- 70-year-old woman mass of 60 kg (healthy range 47–64 kg)
- 70歳女性の体重60 kg（健康範囲は47～64 kg）
- Maximum force she could hit the ground is:
- 彼女が地面に衝突できる最大の力は：
- 60 x 9.80665 = **588.4 Newtons**
- 60 × 9.80665 = 588.4 ニュートン

Body Surface Area (BSA)

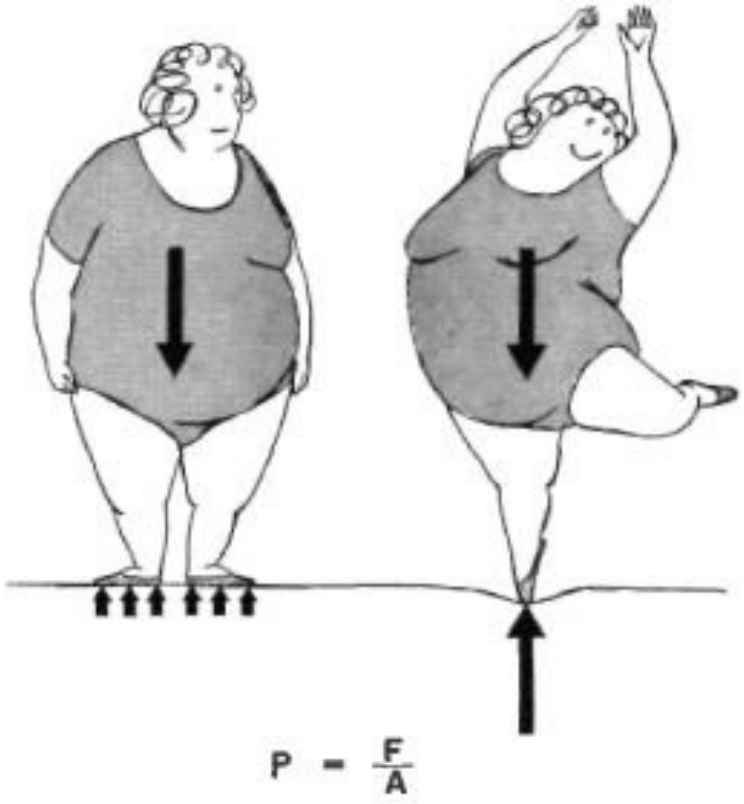
- 1.6 m tall, 60 kg person
- Using Du Bois formula
- BSA is **1.6221 sqm**

Body Surface Area (BSA)

- Approximately 14% of BSA contacts the ground during yoko-ukemi
- 横受身中、体表面積の約14%が地面に接触します。
- 14% x 1.6221 m^2 = 0.227 m^2
- Ukemi techniques spread impact across a large BSA, reducing the injury risk
- 受身の技術は、体表面積の広い範囲に衝撃を分散させ、怪我のリスクを軽減します。
- Due to reduced pressure
- 圧力が軽減されるため

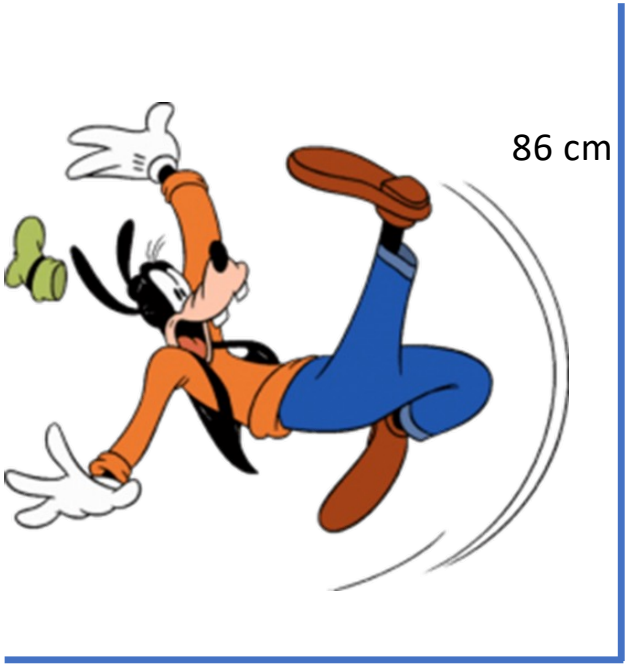

Why does the mattress sink more when I am standing compared with when I am lying?
(a)
(b)

Pressure (Force per unit Area)



- P = F / A is the force distributed over a given area
- P = F / Aは、与えられた面積に分布する力である。
  - P is pressure in Pascals (Pa or N/m^2)
  - F is force in Newtons (N)
  - A is area in square metres (m^2)
- The pressure under the fall is what results in injury

Pressure (Force per unit Area)



- 588.4 N / 0.227 m^2 = 2.59 kPa

Stiletto vs Elephant

(60kg/2) / 0.0001m²

= 3,000,000 n/m²

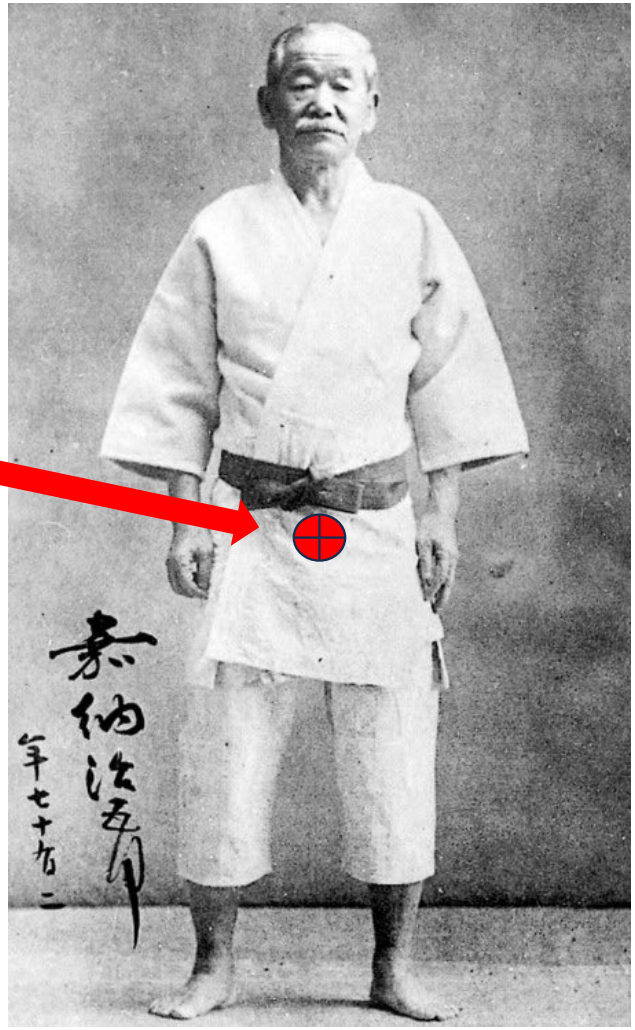
(3,000kg/4) / 0.1m²

= 125,000 n/m²

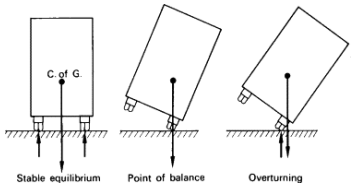
Balance Concepts

Centre of mass

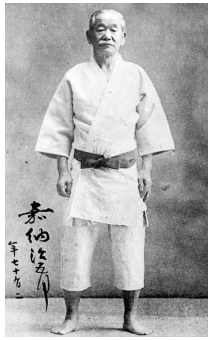
- COM is a theoretical point in an object where its total mass is considered to be concentrated
- COM 物体の全質量が集中していると考えられる理論上の点
- 56% of body height in men
- 男性の場合、身長の56%
- 54% of body height in women
- 女性の場合、身長の54%

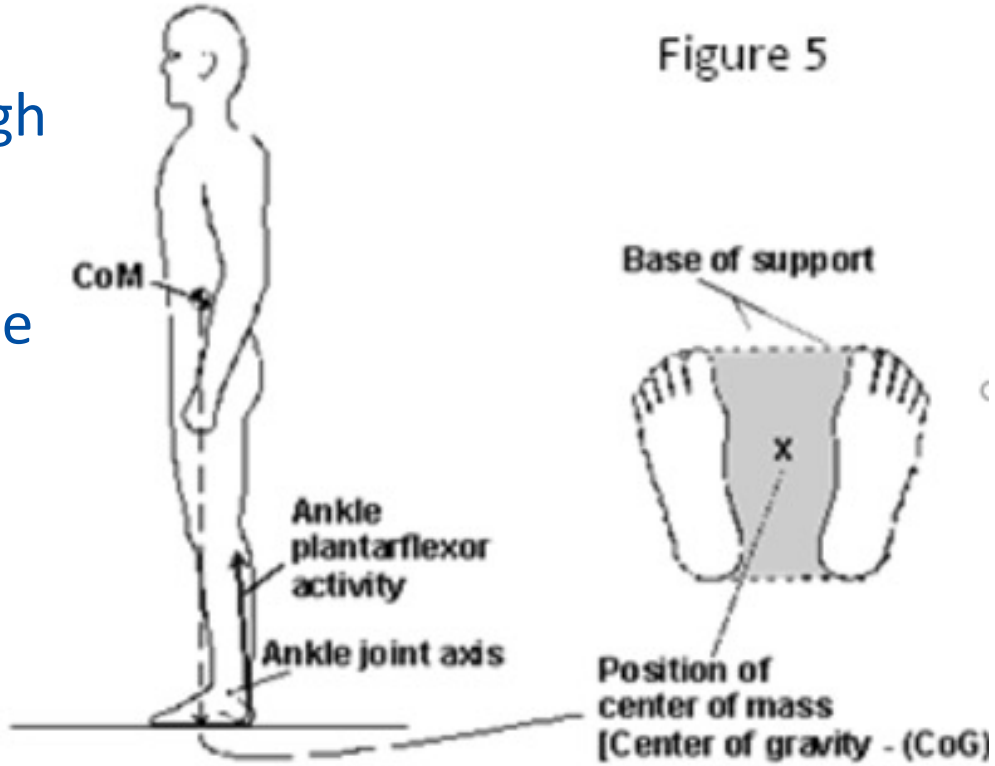


Equilibrium

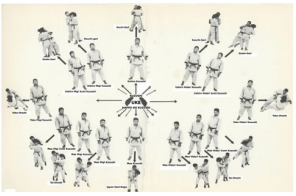


- The state of being on balance
- A vertical line from COM passes through the Base of Support (BOS)
- BOS is the area beneath a person that includes every point of contact with the supporting surface

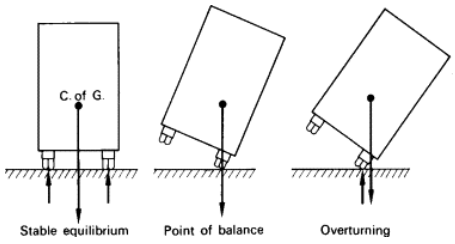


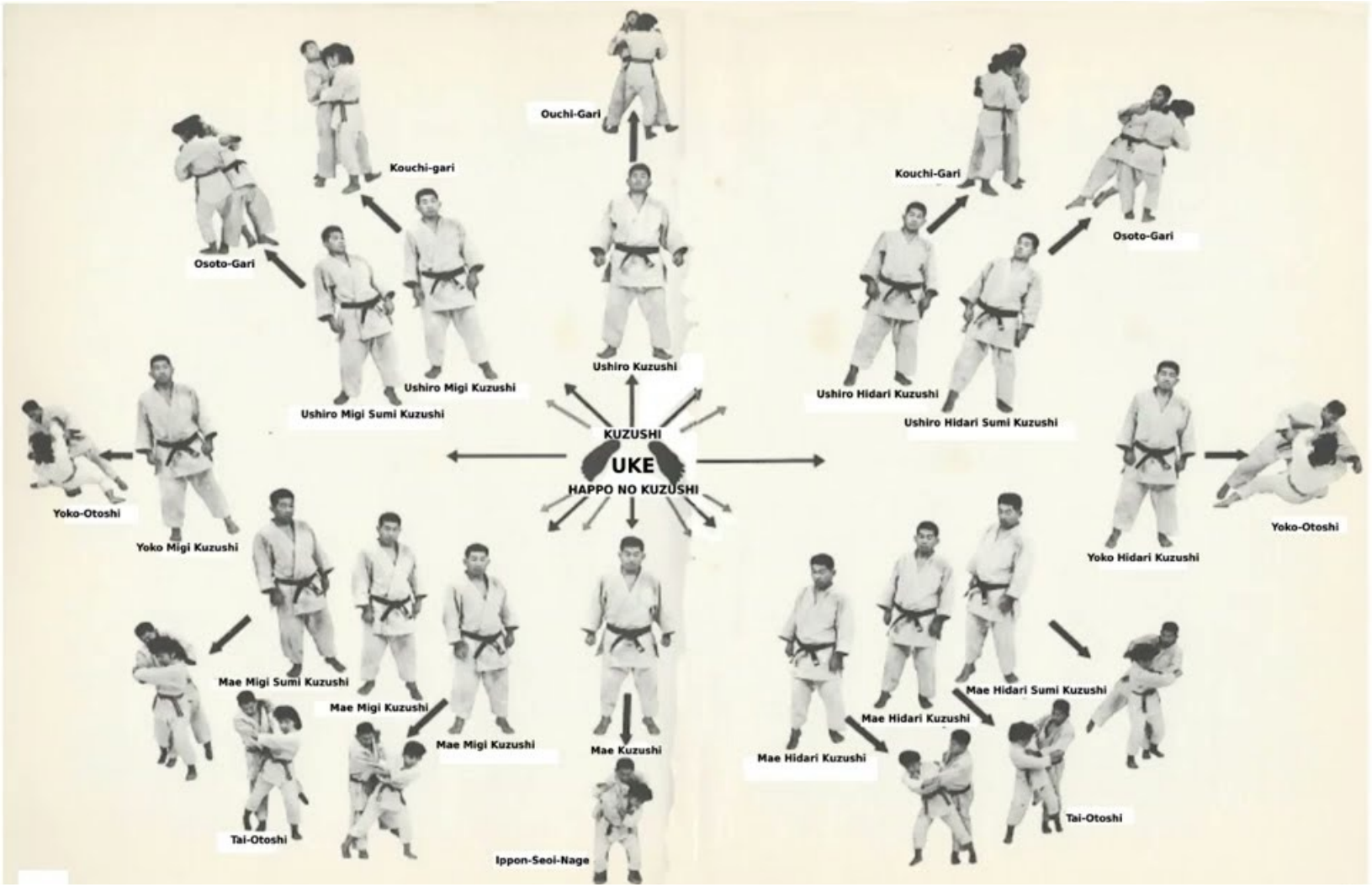


Equilibrium



- Jigotai
- Increases stability
- Lowers COM
- Increases BOS




Ouchi-Gari
Kouchi-gari
Osoto-Gari
Ushiro Migi Kuzushi
Ushiro Migi Sumi Kuzushi
Ushiro Kuzushi
KUZUSHI
UKE
HAPPO NO KUZUSHI
Kouchi-Gari
Osoto-Gari
Ushiro Hidari Kuzushi
Ushiro Hidari Sumi Kuzushi
Yoko-Otoshi
Yoko Migi Kuzushi
Yoko Hidari Kuzushi
Yoko-Otoshi
Mae Migi Sumi Kuzushi
Mae Migi Kuzushi
Mae Migi Kuzushi
Mae Kuzushi
Mae Hidari Sumi Kuzushi
Mae Hidari Kuzushi
Mae Hidari Kuzushi
Tai-Otoshi
Tai-Otoshi
Ippon-Seoi-Nage

Kuzushi

- An action to unbalance your opponent in preparation for throwing him
  - (Kawamura & Daigo, 2000)
- 相手を投げる準備としてバランスを崩す動作
- (Kawamura & Daigo, 2000)
- Position uke whereby the COM passes outside of the BOS
- COMがBOSの外側を通過するポジション受け

Concepts combined to perform yoko-ukemi

- Bending the knees
  - reduces height of COM
- 膝を曲げると重心の高さが下がる
- Falling at an angle rather than vertically
  - Uses the vector element of velocity
- 垂直ではなく斜めに落ちる
- 速度のベクトル要素を使う

Concepts combined to perform yoko-ukemi

- Rolling
  - takes longer to impact the ground
- 転がると
- 地面に着地するまでの時間が長くなる
- Landing on a large % of BSA
  - distributes the pressure
- 体表面積の広い部分に着地すると
- 圧力が分散される

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JUDO

FALL SEVEN TIMES STAND UP EIGHT

七転び八起き