

Biomechanics and Improvements in Training

Principle of Specificity

- In training, replicate: angular displacements and velocities, contraction types, and force magnitudes (muscle, external)
- Identify specific physical and technical requirements of the skill; some skills are more physical (walking), while some are more technical (pole vault)
- Physical and technical facets of a skill often overlap



Types of Training

- Technical Training to improve technique
 - Perform the technique correctly; evaluate performance with a qualitative biomechanical analysis...
 - If you cannot perform the technique correctly...
 - Perform drills that mimic the technique; ensure that the drill is specific to the skill
 - Biomechanics is helpful in quantitatively and qualitatively (more common) evaluating a drill

Types of Training

- Physical training improves physical condition
 - Muscular strength, power, and endurance
 - Cardiovascular fitness
 - Body composition
- First, qualitatively, identify what anatomy should be emphasized
- How is this done?



Qualitative Anatomical Analysis

The best first step may be to identify predominant muscular activity during specific phases of performance, but how is this done?

Some less practical ideas:

- Touch
- Muscle Soreness
- EMG
- Motion Analysis/Inverse Dynamics

Qualitative Anatomical Analysis

A better way, identify:

1. Temporal phases of the skill
2. Joint motions during each phase
3. Muscular contraction type
4. High accelerations
5. Extreme ranges of motion

Table 14.1 Sample Qualitative Anatomical Analysis of a Wide-Grip Bench Press

Joint	Phase of motion	Joint motion	Muscle contraction	Active muscle group	Rapid acceleration or impact	Extreme range of motion
Elbow	Down	Flexion	Eccentric	Extensors	At end of phase	Full flexion at end of phase
	Up	Extension	Concentric	Extensors	At beginning of phase	
Shoulder	Down	Horizontal extension	Eccentric	Horizontal flexors	At end of phase	Full horizontal extension at end of phase
	Up	Horizontal flexion	Concentric	Horizontal flexors	At beginning of phase	

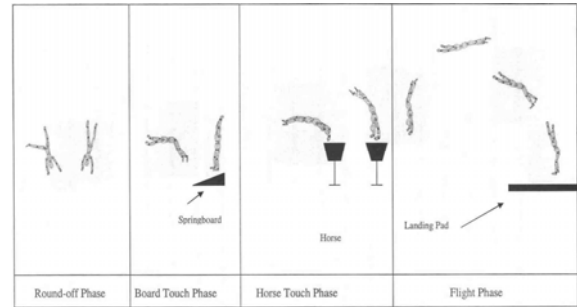
1. Temporal Phase Division

- Do it yourself, if you know the skill well
- A video camera may be necessary
- Study textbooks or coaches manuals
- Examples:
 - Tennis Serve
 - Yurchenko Vault
 - Baseball Pitch

Phases	Description
Wind-up	Starts with ball and racket at rest in front of subject and finishes when ball reaches the level of shoulder height
Early Cocking	Cocking continues from ball at shoulder height until maximal shoulder external rotation. Early cocking makes up the first 75% of this motion
Late Cocking	Represented as the last 25% of the entire cocking motion
Acceleration	Initiates at maximal shoulder external rotation and ends at ball impact.
Early Follow Through	Follow through starts at ball impact and completes when the racket tip reaches its lowest vertical point. Early follow is the first 25% of this motion.
Late Follow Through	Late follow through represents the last 75% of the entire follow through motion.

Seeley et al. (In Press)

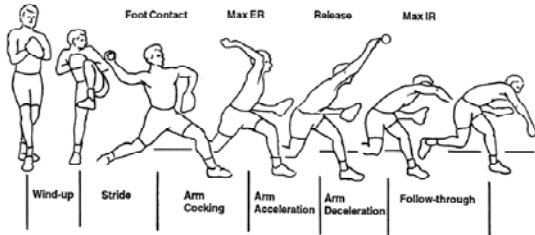
YV Temporal Phases



Seeley & Bressel (2005)

Baseball Pitch Temporal Phases

Fleisig et al. (1999)



2. Joint Motions Fleisig et al. (1999)

Table 1 Kinematic differences among levels

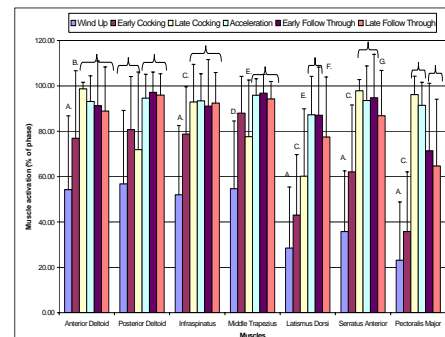
	Youth (n = 25)	High school (n = 33)	College (n = 115)	Professional (n = 68)	Significant differences
Foot-plate contact					
Stride length (% body ht)	85 ± 8	85 ± 9	85 ± 6	86 ± 5	
External rotation (°)	47 ± 20	44 ± 23	39 ± 20	38 ± 20	**No diff
Elbow flexion (°)	74 ± 17	82 ± 17	85 ± 15	87 ± 15	
Knee flexion (°)	41 ± 15	50 ± 9	49 ± 12	46 ± 8	
Arm cocking phase					
Maximum peak velocity (°/s)	650 ± 110	640 ± 90	670 ± 90	620 ± 80	**No diff
Maximum upper torso velocity (°/s)	1100 ± 110	1130 ± 110	1170 ± 100	1200 ± 90	**No diff
Maximum shoulder flexion (°)	95 ± 12	100 ± 14	99 ± 15	98 ± 15	
Maximum horizontal abduction (°)	21 ± 9	20 ± 9	20 ± 8	21 ± 9	
Maximum external rotation (°)	177 ± 12	174 ± 9	173 ± 10	175 ± 11	
Arm acceleration phase					
Maximum elbow extension velocity (°/s)	2230 ± 300	2180 ± 340	2380 ± 300	2320 ± 300	**No diff
Maximum internal rotation velocity (°/s)	6900 ± 1050	6820 ± 1300	7430 ± 1270	7240 ± 1010	**No diff
Ball release					
Horizontal rotation (°)	24 ± 7	23 ± 7	23 ± 6	23 ± 5	
Horizontal abduction (°)	11 ± 9	10 ± 9	9 ± 9	9 ± 10	
Trunk tilt (°)	32 ± 9	3 ± 9	33 ± 10	33 ± 9	
Ball velocity (°)	26 ± 13	41 ± 13	39 ± 11	38 ± 13	
Ball spin rate (°/s)	28 ± 1	31 ± 2	31 ± 2	37 ± 2	**No diff

Note: Significant differences (p < 0.05) between (a) youth and high school, (b) youth and college, (c) youth and professional, (d) high school and college, (e) high school and professional, and (f) college and professional.
 *Significant difference (p < 0.05) among four levels.
 **Significant difference (p < 0.01) among four levels.

3. Muscle Contractions

- Identify which muscles are active, and when each muscle is active
- Identify contraction type for active muscles

Quantitative or qualitative?



4. High Accelerations

- Identify events that result in high accelerations...again, you can employ fancy instrumentation or common sense, or both.
 - Yurchenko Vault
 - Tennis Serve and Baseball Pitch

5. Extreme Ranges of Motion

- Identify events that results in extreme ranges of motion

Table 1
Kinematic differences among levels

	Varsity (n = 75)	High school (n = 15)	College (n = 15)	Professional (n = 40)	Significant differences
Flexion/extension					
Hand length (% height)	87 ± 8	85 ± 9	87 ± 8	88 ± 8	
Shoulder extension (°)	67 ± 28	68 ± 25	65 ± 28	68 ± 28	
Elbow flexion (°)	78 ± 17	82 ± 17	81 ± 15	87 ± 15	**a,b
Knee flexion (°)	65 ± 12	65 ± 9	65 ± 12	68 ± 8	
Arm swing phase					
Maximum pelvic velocity (°/s)	470 ± 110	640 ± 90	470 ± 90	470 ± 80	**b
Maximum upper torso velocity (°/s)	1100 ± 150	1120 ± 110	1100 ± 200	1200 ± 160	**a,b,c,d
Maximum elbow flexion (°)	92 ± 12	100 ± 14	92 ± 12	98 ± 12	
Maximum horizontal abduction (°)	20 ± 7	20 ± 7	20 ± 7	17 ± 7	
Maximum external rotation (°)	178 ± 12	175 ± 9	175 ± 10	175 ± 11	
Arm acceleration phase					
Maximum elbow extension velocity (°/s)	3700 ± 300	5100 ± 500	3700 ± 300	3700 ± 300	**a,b,c,d
Maximum external rotation velocity (°/s)	4000 ± 300	4870 ± 500	4210 ± 470	3720 ± 300	**a
Ball release					
Elbow flexion (°)	74 ± 7	73 ± 7	71 ± 6	71 ± 5	
Horizontal abduction (°)	11 ± 9	10 ± 6	9 ± 9	8 ± 10	
Trunk tilt (°)	83 ± 6	78 ± 6	75 ± 6	71 ± 6	
Knee flexion (°)	36 ± 11	43 ± 11	39 ± 11	38 ± 11	
Ball speed (m/s)	29 ± 1	33 ± 2	33 ± 2	37 ± 2	**a,b,c,d,e

Note: Significant differences (p < 0.05) between (a) varsity and high school, (b) varsity and college, (c) varsity and professional, (d) high school and college, (e) high school and professional, and (f) college and professional.
 *Significant difference (p < 0.05) among four levels.
 **Significant difference (p < 0.001) among four levels.

Table 14.4 Sample Qualitative Anatomical Analysis of a Sprinting Stride

Joint	Frames	Joint motion	Muscle contraction	Active muscle group	Rapid acceleration or impact	Extreme range of motion
Left hip	1-2	Flexion	Concentric	Flexors	Yes	Hyperextension
	2-3	Flexion	Concentric	Flexors		
	3-4	Flexion	Concentric	Flexors		
	4-5	Flexion	Eccentric	Extensors	Yes	
	5-6	Extension	Concentric	Extensors		
	6-7	Extension	Concentric	Extensors		
Left knee	1-2	Flexion	Concentric	Flexors	Yes	Hyperextension
	2-3	Flexion	Eccentric	Extensors	Yes	
	3-4	Extension	Concentric	Extensors	Yes	
	4-5	Extension	Concentric	Extensors	Yes	
	5-6	Extension	Eccentric	Flexors	Yes	
	6-7	Flexion	Eccentric	Extensors	Yes	
Left ankle	1-2	No motion	isometric	Dorsiflexors		Plantar flexion
	2-3	Dorsiflexion	Concentric	Dorsiflexors		
	3-4	Dorsiflexion	Concentric	Dorsiflexors		
	4-5	Dorsiflexion	Eccentric	Plantar flexors		
	5-6	Plantarflexion	Concentric	Plantar flexors		
	6-7	Dorsiflexion	Eccentric	Plantar flexors	Ground impact	
Left shoulder	1-2	Plantar flexion	Concentric then eccentric	Plantar flexors then dorsiflexors	Yes	Plantar flexion
	2-3	Extension	Concentric	Extensors		
	3-4	Hyperextension	Concentric	Extensors	Yes	
	4-5	Hyperextension	Concentric	Extensors		
	5-6	Flexion	Concentric	Flexors	Yes	
	6-7	Flexion	Concentric	Flexors		

Summary

- Biomechanics can be used to improve training and performance
- Principle of specificity leads to performance of the skill or drills that mimic the skill
- Technical versus physical training
- Qualitative Anatomical Analysis
 - Temporal phases
 - Involved joints and motions
 - Involved muscle and type of muscular contraction
 - High accelerations and impacts
 - Extreme ranges of motion