PLYOMETRICS & JUMP TRAINING

SPRINZ / SESNZ STRENGTH & CONDITIONING CONFERENCE 2024

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WHAT ARE PLYOMETRICS?

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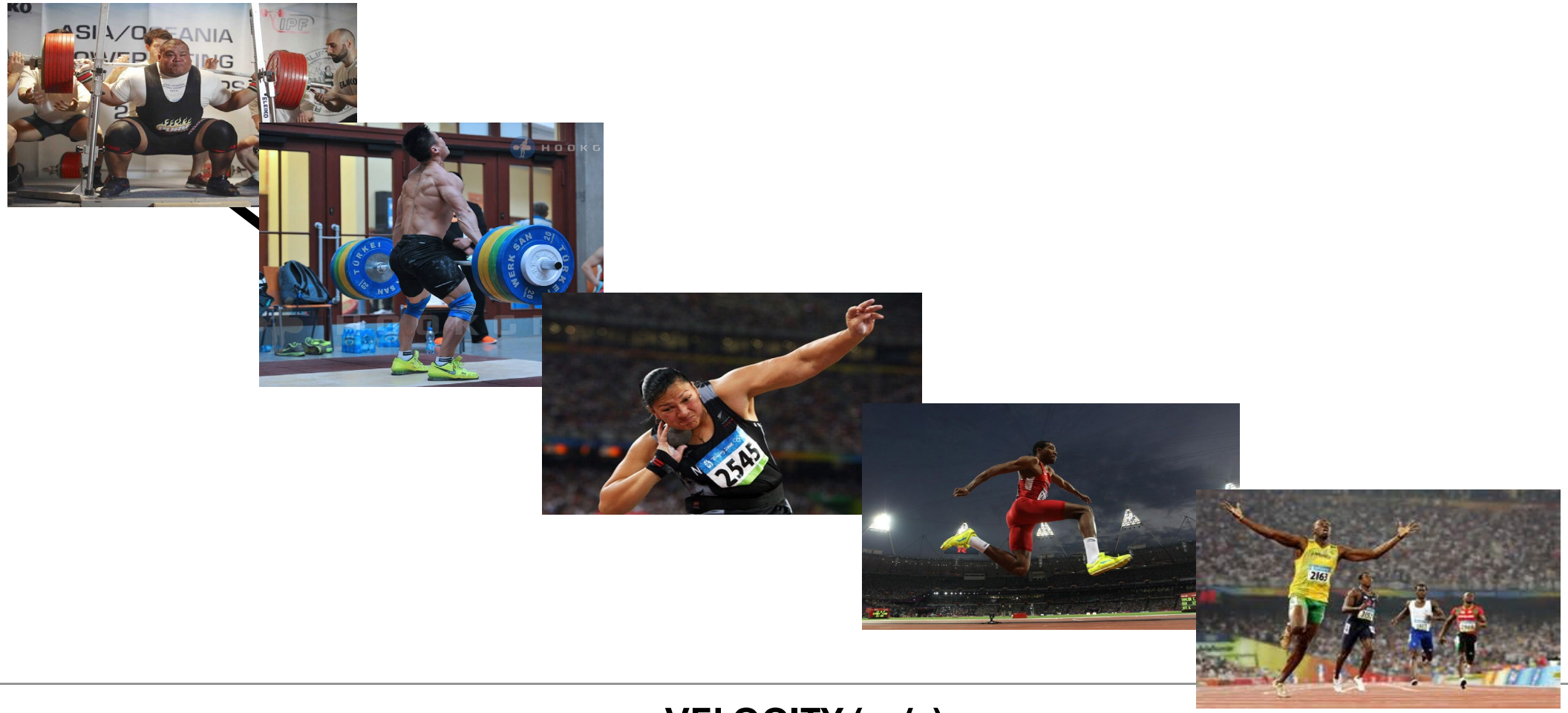
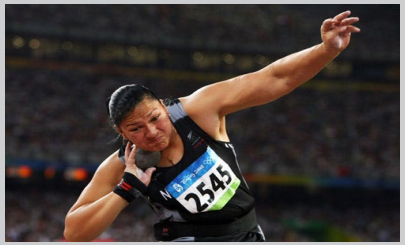
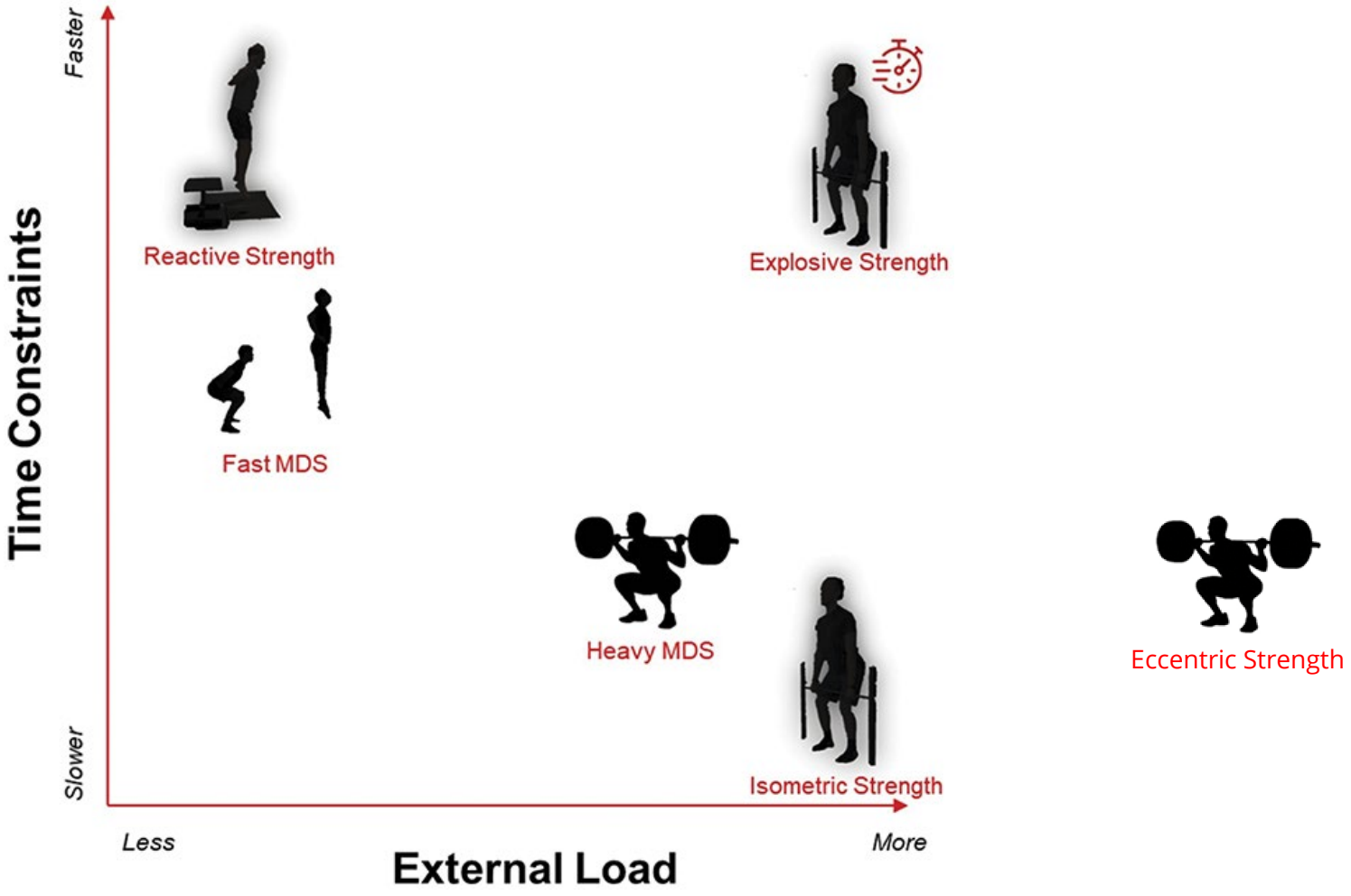


WHAT ARE PLYOMETRICS?



VELOCITY (m/s)

STRENGTH QUALITIES



Adapted from James et al, 2023

FAST DYNAMIC STRENGTH

- Expression of force produced maximally against no or little additional load over brief durations (e.g., ~300ms) (James et al, 2023)
- CMJ and SJ are most common tests of fast maximal dynamic strength
  - Shared variance to other strength qualities 20-40% based on population and training status (James et al, 2023)
- Professional basketball players CMJ 726ms, CMJA 782ms (Cabarkapa et al, 2023)
  - Approx 50% faster concentric:eccentric
- CMJ or SJ height only describes only 45–65% of what occurs in during the CMJ (James et al, 2021)
  - Output variable (e.g., height, take-off velocity, relative peak power)
  - Time variable (e.g., TTO/contraction time, time to peak power)
  - Can supplement these with other variables like CM depth or RSImod (JH/CT)

REACTIVE STRENGTH

- Ability to produce force in a fast stretch shortening cycle (SSC) with ground contact times < 250ms (Schmidtbleicher, 1992)
- Measure of an athlete's ability to tolerate and use high SSC loads
  - Strong correlation with high eccentric demands activities e.g., sprinting, COD, jumping from approach
- Seems independent of the other strength qualities
  - E.g., closest relationship is fast maximal dynamic strength (CMJ) with up to 35% shared variance
  - RSI v RSImod 22% shared variance (McMahon et al, 2021)
- DJ from increasing heights is most common assessment for reactive strength
  - "Jump for maximal height with minimal contact time"
- Other options include 10-5 RJT and rebound CMJ (Comyns et al, 2019)
  - Require less familiarization, may better indicate repeated reactive strength (e.g., sprinting) vs one-off DJ effort

JUMP ASSESSMENTS & VARIABLES

WORKING BACK FROM THE SPORT

- Contact/contraction time constraint focus
- Relevant training activities and contraction times for elite athletics (Coyne, 2021)
  - Unilateral
    - Sprinting 90-100ms
    - Long jump 120-135ms
    - High jump 150-190ms
  - Bilateral
    - Discus and javelin transition and delivery 300-400ms
    - Shot put transition and delivery 380-440ms
- Professional basketball players CMJ 726ms, CMJA 782ms (Cabarkapa et al, 2023)
  - Approx 50% faster concentric:eccentric
- College basketball players 1L “lay-up” jump 218ms (Miura et al, 2010)

RELEVANT ASSESSMENTS

Question	Assessment
Does the athlete need more force or more velocity to improve performance?	Samozino F-V profile (NCMJ or CMJ) Bosco F-V index (CMJ+100%BW/CMJ) DSI (NCMJ or CMJ concentric PF/IMTP PF)*** EUR I (CMJ/NCMJ)
What does an athlete's "movement signature" tell us about how we could improve performance?	Individual ROM signature Individual eccentric/concentric force signature Individual time signature (CMJ, 10-5RSI) Repeated pogo/10-5RSI
Does the athlete need more of a certain type of contraction (e.g., eccentric work) to improve performance?	Individual eccentric/concentric force signature Accentuated Eccentric Jump Profile EUR I (CMJ/NCMJ) Depth/Drop Jump Height Profile
Does the athlete need to improve their sequencing and coordination to improve performance?	Bosco Coordination Index (CMJ-A/CMJ) EUR II (Repeated CMJ/CMJ) Approach Index
Does the athlete need to focus more on unilateral or bilateral work to improve performance?	Asymmetry Index Bilateral Deficit

Coyne, 2021


用兵一时，此时不搏，更待何时
CHINA


用兵一时，此时不搏，更待何时
CHINA

FAST DYNAMIC STRENGTH

- Eccentric Utilisation Ratio (McGuigan et al, 2006): CMJ / NCMJ (SJ) (Komi & Bosco, 1978)
- Baker (1996) improving CMJ based on low EUR (<10%) vs high EUR (>20%)
- No relationship between EUR and performance in Volleyball players (Kozinc et al, 2021)
  - Lower EUR may be desirable for certain sports / tasks e.g., block start
    - High EUR greater muscle-tendon slack? Or poor RFD e.g., ability to take up M-T slack? (Van Hooren & Zolotarjova, 2017)
- Can use any movement to get an indication of athlete's EUR
- Recommendations: RFD intervention vs SSC intervention question
  - Should be viewed in context of overall JH and PP/MP

ELITE SPRINT & HORZ JUMP 2016-17

Jump Type		FT (ms)	Jump Height (cm)
CMJ	MEAN	670.84	55.28
	SD	29.59	4.93
NCMJ/SJ	MEAN	632.46	49.11
	SD	22.47	3.50
EUR	MEAN	6.13%	12.83%
	SD	4.64%	10.01%

Coyne, unpublished

FAST DYNAMIC STRENGTH

- Samozino F-V profile (NCMJ or CMJ)
  - 0, 20, 40, 60, 80, 100%BW
    - 0, 30, 60%BW vs 0, 50, 100%BW
  - F0, V0, Sfv, FVopt, Rel Pmax
    - FVopt can modify based on force vector e.g., sprint start vs vertical jump
  - Wild (2023): Rel Pmax team sport 35-40W/kg
  - Coyne (2021): Rel Pmax LJ CMJ 40-45W/kg, Sprint CMJ 55-60W/kg
    - Training history for LJ athletes?
  - Coyne (2023): Rel Pmax Male Swim NCMJ 35-40W/kg, Female Swim NCMJ 30-35W/kg

REPEATED REACTIVE STRENGTH

- 10-5 RJT and rebound CMJ (Comyns et al, 2019)
  - Indication of repeated reactive strength (e.g., sprinting) vs one-off DJ effort
- Variables include jump height, contact time, RSI (JH or FT/CT)
  - Wild (2023) 10-5: Team sport JH > 20cm, CT < 230ms
  - Coyne (2021) 10s: LJ JH > 28cm, CT < 275ms, Sprint* JH > 20cm, CT < 244ms
    - Training history for sprint athletes?
- Can also examine BLD, Coordination Index and Asymmetry

ELITE SPRINT & HORZ JUMP 2016-17

Jump Type		FT (ms)	CT (ms)	Jump n	Jump Height (cm)	RSI (ms/ms)
2L arms 10s	MEAN	632.64	201.73	12.55	49.47	3.23
	SD	60.35	42.50	1.57	8.90	0.55
2L no arms 10s	MEAN	566.83	172.33	14.00	39.87	3.35
	SD	69.21	35.98	1.67	9.37	0.50
1L arms 10s	MEAN	457.42	265.58	14.33	25.88	1.74
	SD	45.29	34.58	1.23	5.14	0.24

Coyne, unpublished

ELITE SPRINT & HORZ JUMP 2016-17

		FT	CT	RSI
Asymmetry L-R	MEAN	4.4%	6.7%	-1.5%
	SD	8.0%	7.0%	12.4%
Coordination Index	MEAN	-8.1%	-2.2%	-4.8%
	SD	1.6%	12.9%	11.2%
BLD	MEAN	148.9%	204.0%	119.2%
	SD	7.1%	35.5%	15.8%

Coyne, unpublished

PLYOMETRIC PROGRAM DESIGN

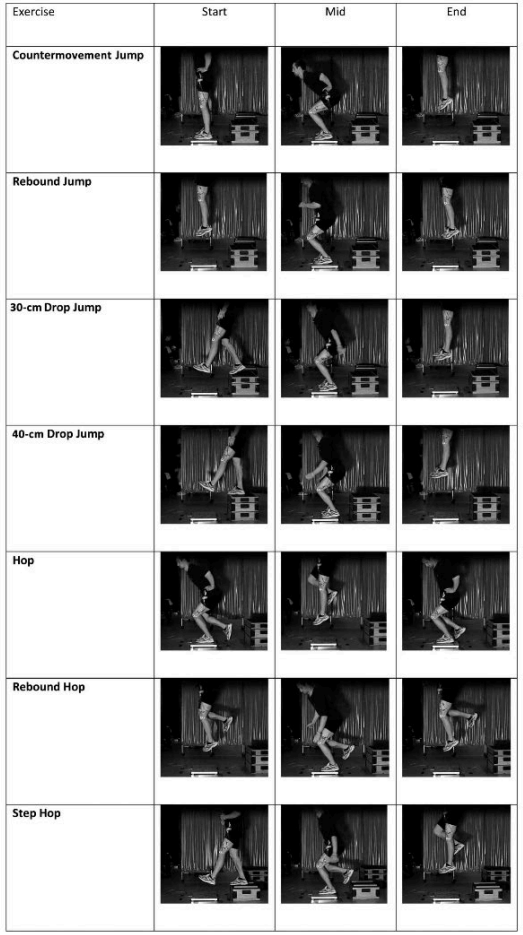
LITERATURE RECOMMENDATIONS

- Volume recommendations based on number of contacts (Potach & Chu, 2016)
  - 80–100 beginners
  - 100-120 for intermediate
  - 120-140 for advanced
- 2x week, >50 contacts/session and >20 sessions seems to be minimum dose (de Villarreal et al, 2009)
  - Low and moderate volume (60-120 contacts/week for 7 weeks) potentially better than high volume (240 contacts) (de Villarreal et al, 2009)
  - Variety of plyometric movements better than single movement (de Villarreal et al, 2009)
- Used in combination with TRAD (Markovic & Mikulic, 2010)

PLYOMETRIC INTENSITY

- Intensity of any jumping can be expressed in different ways
  - Simple: relative to maximal CMJ
  - Complex: PF, impulse and peak eccentric power distinguishes between plyometric exercises and greater intensity in “rebound” vs ballistic activities (Jarvis et al, 2016)
    - Use PF instead of drop height for plyometric intensity measures and impulse for session volume (Jarvis et al, 2016)
  - Practically hard to measure consistently across different jump variations, even if you complete all your jumps on force plates.
- Suggest base program design off sound progressions, which will naturally manage intensity
  - Plyometric continuum (Wilmot, 2021)

INTENSITY



	Rel peak GRF				Rel peak ECC power				Rel impulse			
Exercise	Mean ($N \cdot bw^{-1}$)	*SEM*	ICC	SDD	Mean ($W \cdot bw^{-1}$)	*SEM*	ICC	SDD	Mean ($Ns \cdot bw^{-1}$)	*SEM*	ICC	SDD
CMJ	2.5	0.1	0.96	0.2	−1.66	0.1	0.95	0.3	0.25	0.005	0.91	0.01
RB	4.48	0.4	0.90	1.0	−7.53	0.7	0.92	2.0	0.46	0.010	0.96	0.03
DJ30	3.79	0.2	0.85	0.6	−7.61	0.4	0.91	1.2	0.48	0.004	0.99	0.01
DJ40	4.4	0.3	0.97	0.9	−10.26	0.6	0.97	1.7	0.51	0.005	0.97	0.01
Hop	1.86	0.0	0.99	0.1	−0.99	0.1	0.88	0.3	0.16	0.004	0.94	0.01
RBHop	2.92	0.1	0.87	0.3	−4.04	0.3	0.93	0.7	0.34	0.010	0.96	0.03
Step	2.52	0.1	0.87	0.3	−4.61	0.3	0.85	0.7	0.34	0.005	0.93	0.01

*ICC = intraclass correlation coefficient; SDD = smallest detectable difference; CMJ = countermovement jumps; RB = rebound jump; DJ30 = 30-cm drop jump, DJ40 = 40-cm drop jump; RB = rebound; RBHop = rebound hop.

Bilateral Deficit (RBHop *2 / DJ40) = 1.33 PF, 0.78 EccP, 1.41 Imp

Jarvis et al, 2016

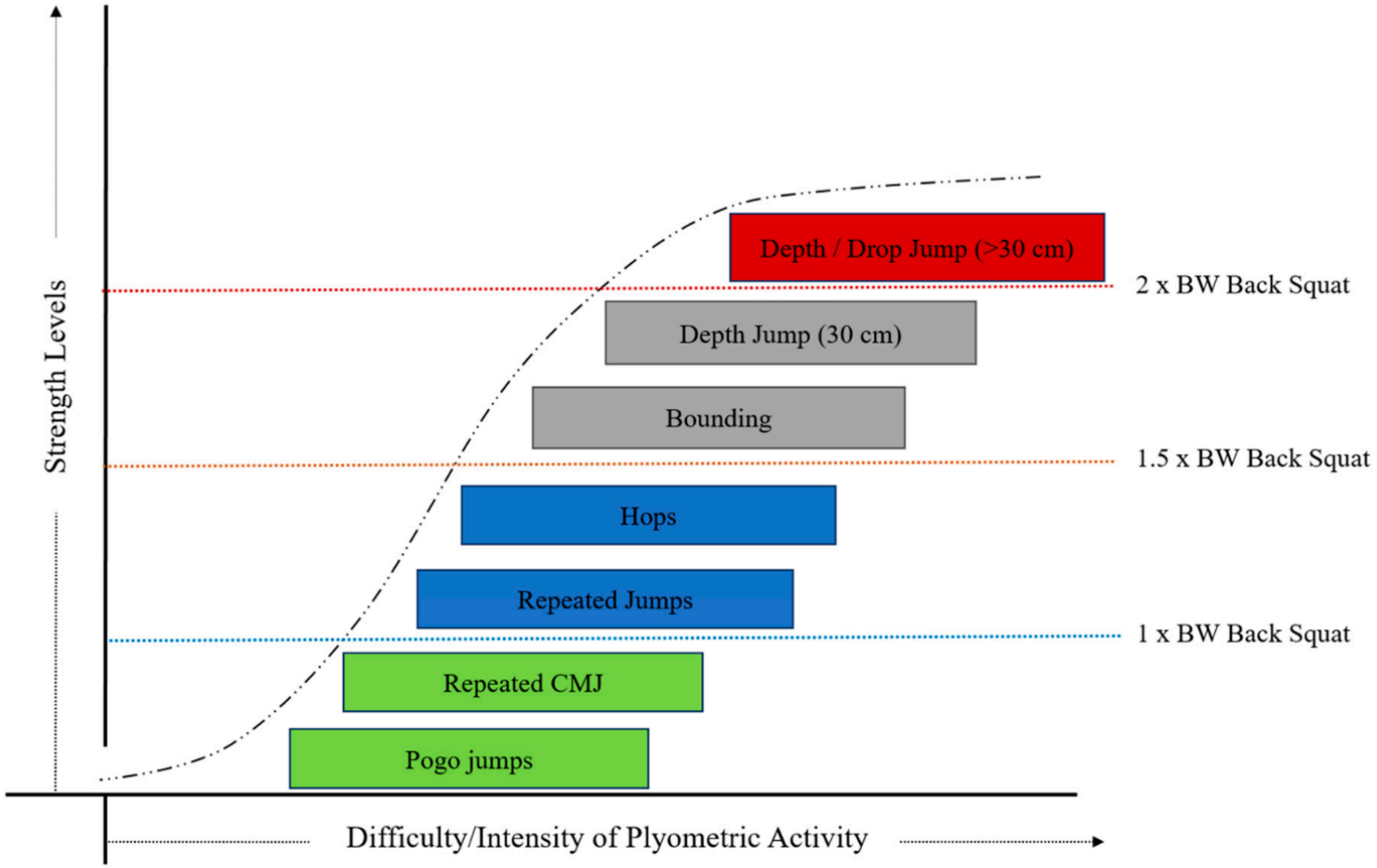


Figure 3. Theoretical relationship between strength and the optimization of plyometric exercise performance. Adapted from Suchomel et al. [93], Buchner et al. [99], and Haff [100] BW = body weight.

Suchomel et al, 2021

PLYOMETRIC VOLUME

- Practical measure: likely minimum volume threshold (de Villarreal et al, 2009)
  - 50 contacts per leg per session
  - 100-150/plyometric contacts per week per leg
  - Guideline is for OUTSIDE “technical” training (Coyne, 2023)
    - Volume also needs to be considered with any sprinting and high intensity running work done in the same week and actual jumping ability of an athlete.
    - If an athlete is not experiencing many plyometric contacts in technical training (e.g., from jumping, COD, or sprinting), up to 2 more plyometrics sessions…
    - Bearing in mind the overall plyometric contacts/week does not get too excessive for the athlete’s capabilities

PLYOMETRIC VOLUME

- As athletes get more advanced; naturally progress to more advanced plyometrics
- When advancing plyometric intensity, normally recommend simply keeping same contact volume per week
  - I.e., minimum effective volume with increased intensity
- However, some athletes may be able / need to be progressed to much higher levels of contact volume to maintain or improve SSC ability.
  - E.g., 2017 Chinese national long jump squad: often accumulated >350 loaded and unloaded plyometric contacts each week in 3 “non-technical” training sessions

PROGRAM DESIGN

Exercise	Sets	Reps	Rest	Plyometric Contacts per Leg
A1: Band Resisted Bounds	2	10 each leg	As needed	20
A2: 1-2 CMJ	2	6 each leg	As needed	12
B: Pogo Jumps	3	6	As needed	18

Coyne, 2023

PROGRAM DESIGN

- Simple plyometric (and strength) training framework (Coyne, 2023)
  - Normally 2 days / week OUTSIDE of technical training
  - Aim to exploit post activation potentiation as much as possible BUT should compare contrast vs compound
- Developed jumping ability and good lower body force expression (Coyne, 2023)
  - One “power” day (compound)
    - Session framework consists of a bi-, tri- or quad-set of “fast”, “moderate” or “slow” jumps
    - Balanced intervention: one of each e.g., similar to French contrast
    - Targeted intervention: bias towards one type of jump e.g., “fast jump intervention: “fast”, “moderate”, “fast” tri-set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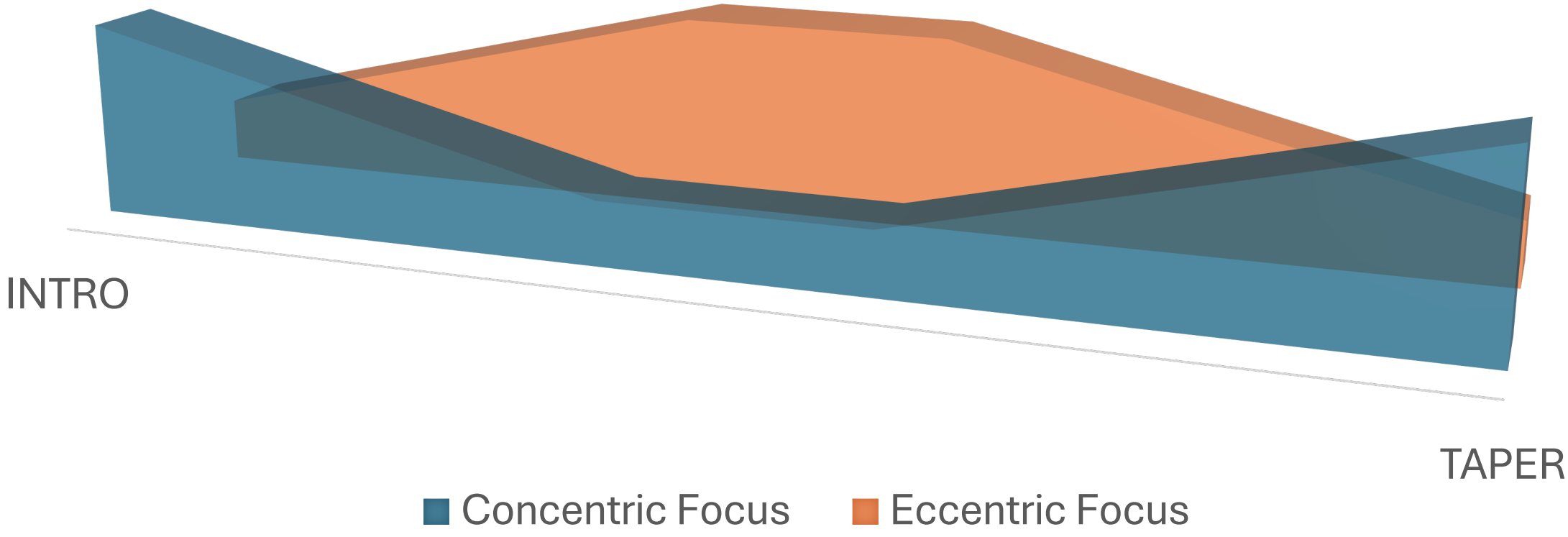
DIMA
DIMA

PROGRAM DESIGN

- One “maximal strength” day (Coyne, 2023)
  - Less jumping compared to the “power” day
  - Session framework consists of strength exercise with targeted jump (contrast) e.g., athlete diagnosed to need more force to improve Rel PP, “slow” jump paired with the maximal strength lift
- Lower-level jumping ability and poor lower body force expression (Coyne, 2023)
  - Two “maximal strength” days

PROGRAM DESIGN

- Periodisation of plyometrics with the strategic focus on different contraction types (Coyne, 2023)
  - Different ways to periodise plyometrics inter-session (e.g., linear/block, concurrent) and intra-session (e.g., contrast, compound)
  - Tend to use concurrent approach (e.g., vertical integration) with athletes as much as possible.
    - All athletes will be doing some type of plyometric training throughout preparation periods
    - Aligns with duration and variety suggestions from de Villearreal et al, 2009 and TRAD inclusion from Markovic & Mikulic, 2010
- Blended with additional layer of eccentric or concentric accentuation (Coyne, 2023)



Coyne, 2021

PROGRAM DESIGN

- Different contraction accentuation methods potentially very relevant for sports that involve a lot of jumping
  - E.g., basketball, volleyball, field jumping events
- Fine art in balancing “relevant” plyometric activity with what an athlete does regularly in their sport
  - Overloading too much of the same stimulus to cause a performance regression?
- Athletes in “jumping” sports are unlikely to get performance benefits from simply adding more jumping volume to training
  - Different contraction accentuation methods provide a different plyometric stimulus than technical training
  - Can help drive performance improvements and resilience to injury for “jumping” sport athletes

THANKS!

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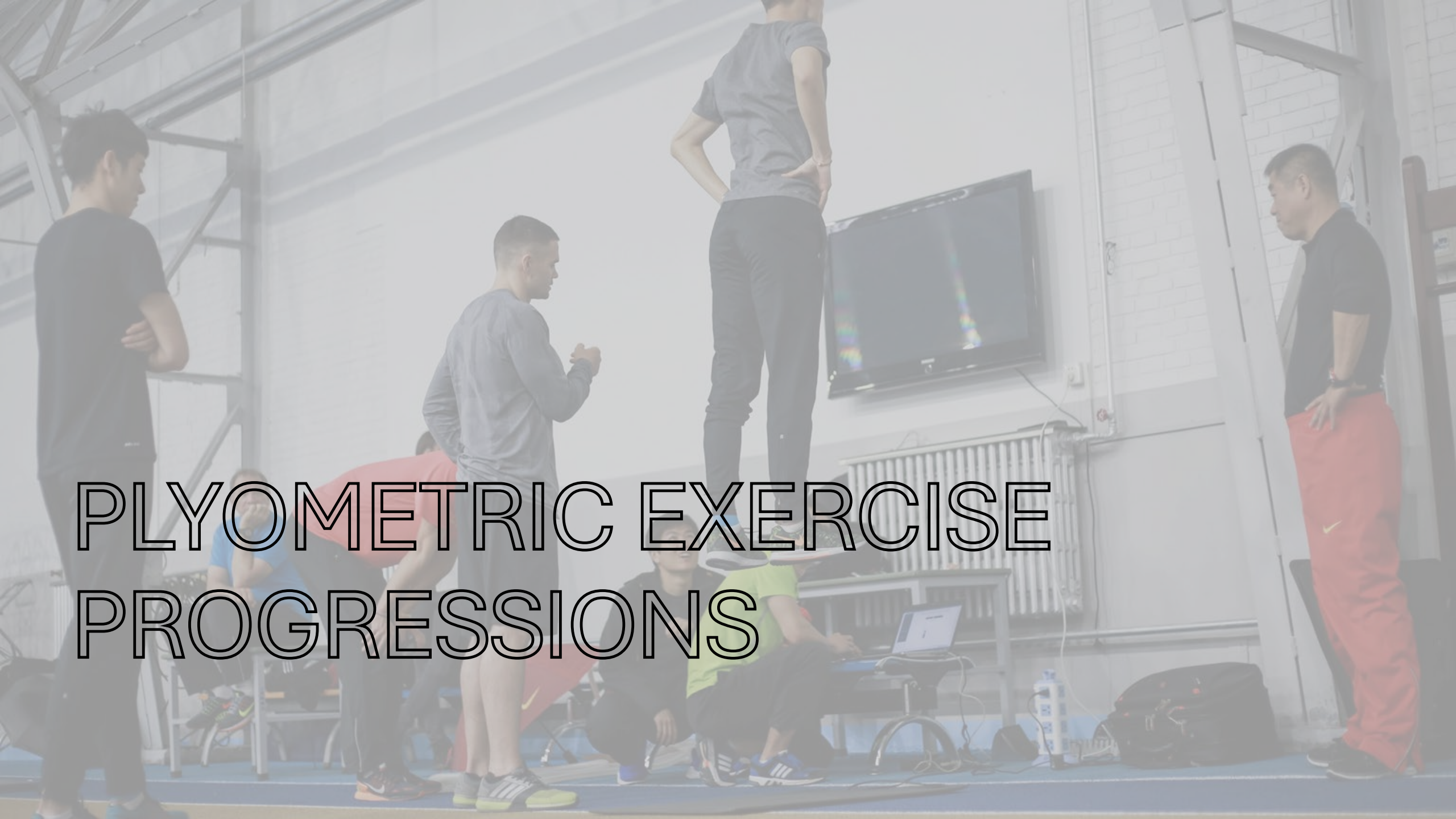
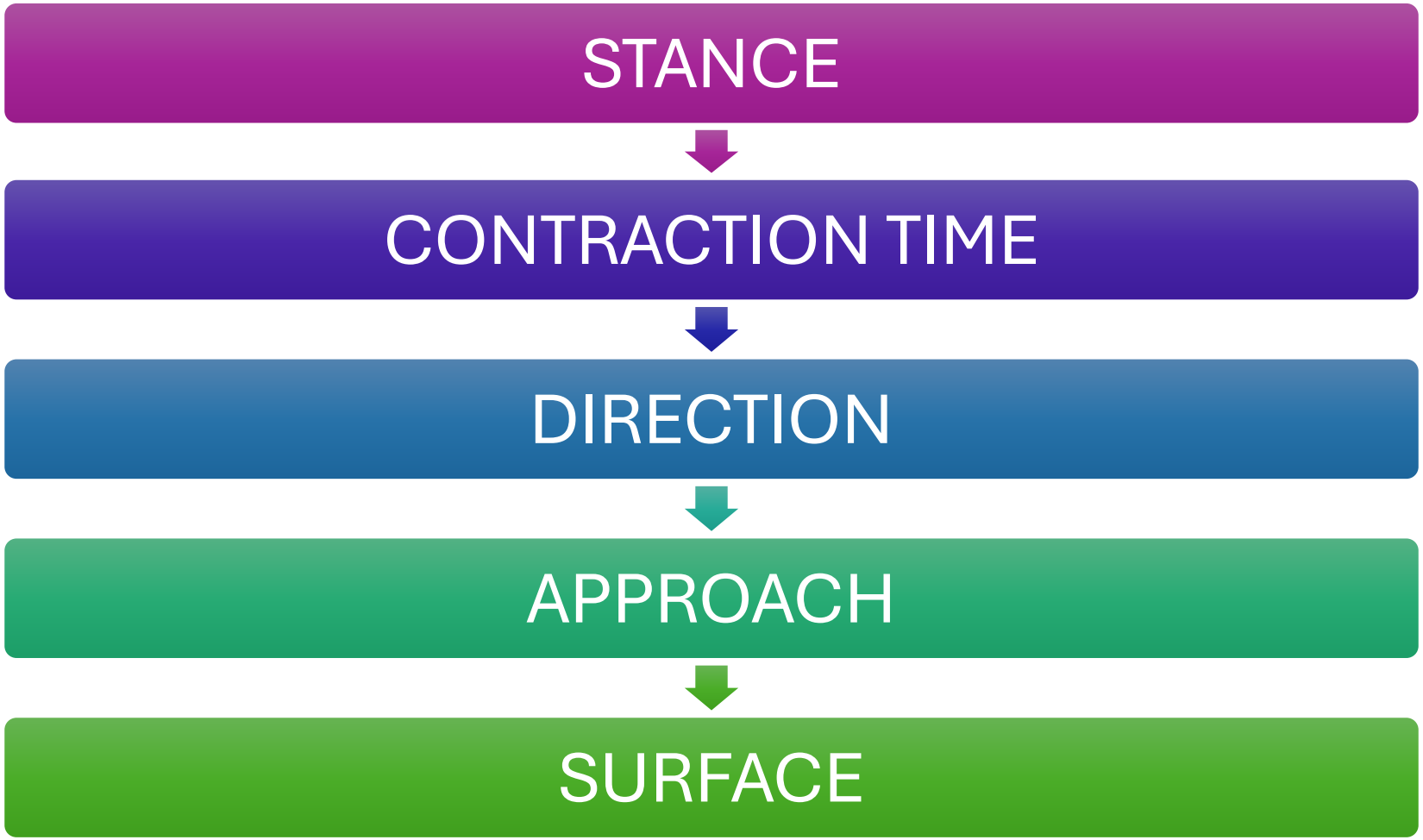


PLYOMETRIC EXERCISE PROGRESSIONS

PLYOMETRIC EXERCISE VARIABLES



Coyne, 2021

STANCE

- Fundamental questions
  - “Is force produced from a bilateral or unilateral stance?”;
  - “If force is predominately produced from a bilateral/unilateral stance, are we improving force production from this stance in our training?”
- Worthwhile considering if bilateral stances are split
  - Jumping from split stance can be very different from a “true” bilateral stance

CONTRACTION TIME

- Indication of where to focus plyometric efforts
- Argument for doing any type of long CT jumps for short CT activities may be limited and vice versa e.g., volleyball spike jump, snatch
  - Ruffieux et al (2020): greater improvements in volleyball-specific jumping following predominately CMJ training (similar CT to most volleyball-specific jumps) vs. predominately DJ training (shorter CT than most volleyball-specific jumps) over six weeks
- Practical experience, ~100ms bilateral and ~150-200ms unilateral bandwidth above and below the target activity you want to target
  - E.g., for sprinting, jumps with CT below ~200ms for bilateral jumps and ~300ms for unilateral jumps (e.g., bounds or pogo-type jumps)
    - Unilateral jumps take relatively longer for athletes to generate enough force
  - Exception: depth jumps from box higher than CMJ height: 350-400ms CT for both bilateral / unilateral jumps

DIRECTION

- Nature of the sport / position important
  - E.g., track and field sprinters / jumpers: vertical and horizontal versus field/court sports all four directions relevant.
    - Linear, lateral and rotational
  - “Less relevant” jumping work (i.e., in directions outside what is in the sport) can still have indirect benefits
    - Sugiura et al (2017) inclusion of lateral and rotational jumps reduce injury risk in sprinters.

APPROACH

- Approach into any jump critical
  - Most jumps in sport rely on an approach
  - However, most jump training seems to rely on mostly jumps with no approaches?
- Final stage of any approach in jumping normally involves 3 components: the penultimate step, the transition (or “cut step”), and the ultimate, block or take-off step
- Some differences between a unilateral or bilateral take-off
  - E.g., in bilateral take-off, block step becomes penultimate step, also coupled with a common pivoting action and knee valgus with an extra step
- Recommendation
  - Simple 1-, 2- and 3- step approaches in repeated jumping drills
  - Trained both linear and curvi-linear approaches


更高
更快
更强

SURFACE

- Surfaces generally range from closed (e.g., track, rubber floor, hardwood court) to quasi-closed (e.g., sand, trampoline).
  - Contraction times normally longer in lower level or less explosive athletes and on different surfaces e.g., grass
- Benefits to jumping on surfaces other than competition surface
  - Reductions in lower muscle soreness and joint load with softer “closed” surfaces
  - Potential “overspeed” benefits of jumping on surfaces that give athletes some extra bounce
- Benefits to jumping on quasi-closed surfaces (e.g., sand)
  - Improvement in foot function with low amplitude jumps
  - Skill acquisition/contrast effect when returning to the surface normally compete on
  - Impellizzeri et al (2008): professional soccer less muscle soreness and improved NCMJ performance from sand versus grass
  - Vuong et al (2023): professional basketball significant improvement in CMJ, pivot step jump, 5-20m sprint times from sand vs hard surface

PLYOMETRIC COMPONENTS

DOMINANT MOTOR PATTERN

JUMP	BOUND	HOP
2L-2L	L-R/R-L	L-L/R-R

Adapted from EXOS, 2014

PLYOMETRIC COMPONENTS

DOMINANT FORCE VECTOR(S)

VERTICAL VS HORIZONTAL?

- LINEAR
- LATERAL
- ROTATIONAL

Adapted from EXOS, 2014

PLYOMETRIC COMPONENTS

DOMINANT CONTRACTION NATURE

DURATION

CONC vs ECC ACCENTUATED?

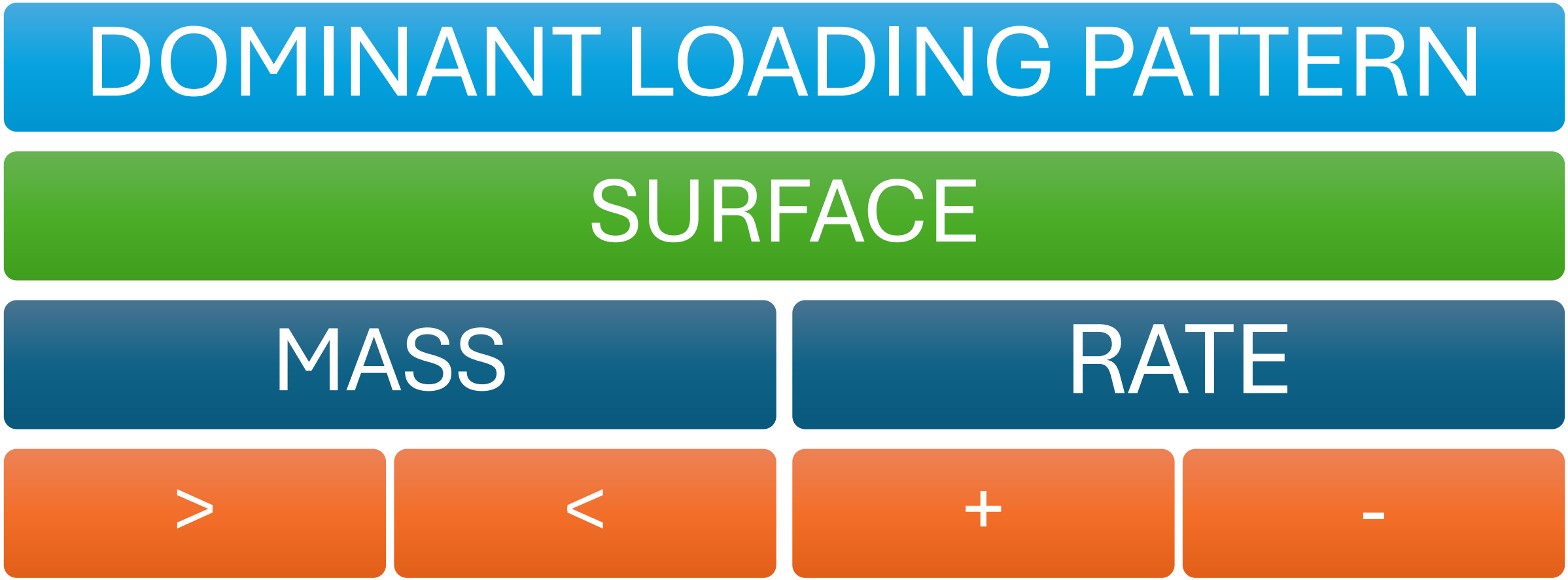
NCM	CM	DC	DEP	CONT

Adapted from EXOS, 2014


PAIS
HART


SOFT
45CM
18"
FIRM
UFC

PLYOMETRIC COMPONENTS



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IRONEDGE
10 KG


EVIL RUNNING
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THANKS!

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