[Athletic Training]

CEU

Data-Based Interval Throwing Programs for Baseball Players

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Context: Baseball throwing injuries are common. Emphasis on injury prevention and rehabilitation is made in an attempt to keep athletes on the field of competition. Interval throwing programs are an integral part of training, conditioning, and returning an injured baseball player to the game.

Evidence Acquisition: Development of data-driven programs was based on the number, type, distance, and intensity of throws during games, across the spectrum of ages and positions for baseball athletes at all levels of play. Statistical analysis by age, position, and level of play determined the need for separate throwing programs. Means, the high range, game rules, and practical considerations were used to develop each data-based interval throwing program.

Results: Data-based age and level-of-play interval throwing programs for pitchers, catchers, infielders, and outfielders have been developed, tested, and implemented for more than 10 years. Progression is based on type and location of injury, symptoms in response to throwing, and preinjury performance profile. Although the throwing programs are highly structured, there is ample opportunity to modify them to meet the needs of individual athletes.

Conclusion: Data-based interval throwing programs for baseball athletes are an integral training and conditioning element for both injured and uninjured athletes who are preparing for sports participation. Medical team members should equip themselves with an understanding of how to use the programs for safe training, conditioning, and return to play.

Keywords: baseball injuries; baseball conditioning; rehabilitation

Described as America's pastime, baseball continues to be popular, from youth to the professional level. Participation in this great sport promotes the development of skill, discipline, and teamwork.[3] Unfortunately, injuries are prevalent. Complaints of shoulder and elbow injury are the most common reasons why a baseball athlete seeks medical attention.[19,20] Most injuries are believed to be a consequence of cumulative micro-trauma from the repetitive, dynamic overhand throwing motion inherent to the sport.[1,16,18] Consequently, effective injury prevention and rehabilitation strategies have become a focal point for specialized physicians, physical therapists, and athletic trainers.

Education and protection are 2 key concepts in baseball injury prevention.[3] Research studies have established a link between throwing volume and shoulder/elbow injuries among youth baseball pitchers.[18,20] These results have prompted the USA Baseball Medical and Safety Advisory Committee to recommend pitch limits for youth pitchers (Table 1).[23] This advisory committee recommends not only monitoring pitch counts but having pitchers (1) compete no more than 9 months in a calendar year, (2) develop and maintain good mechanics, (3) commit to year-round physical conditioning as their bodies develop, (4) participate in only 1 performance as a pitcher per day, (5) avoid showcase

participation, and (6) limit participation to 1 team per season.[23] These recommendations have also prompted the largest youth baseball league to institute rule changes based on pitch counts and types. Although further research is necessary to determine the consequences of throwing breaking pitches before physical maturity, the committee did report that throwing curves and sliders, with poor mechanics, appears to increase the risk of injury.[23]

Young athletes who can throw much further and faster than what age norms dictate are at risk for shoulder and elbow injuries. In a study of more than 750 youth baseball players, normative data were established to categorize and monitor young pitchers (Table 2).[3] If athletes are more than 3 standard deviations above their peers for speed or distance, then they are in an exclusive group (26 of 10 000). If an athlete is 5 standard deviations above one's peers, then he or she may truly be "one in a million." The

growth plates and the ligaments in this special group of players are of concern. Therefore, if an athlete is 3 to 5 standard deviations in throwing velocity or distance beyond one's peers, then 2 years should be subtracted from his or her actual age to determine appropriate pitching volume. For example, if an 11-year-old male is 4 standard deviations above his peers for pitching velocity, then he should follow the pitch-limit recommendations for a 9-year-old. Such special athletes can be identified as early as 8 years of age. If not identified early, then these future superstars, whose growth plates may not be able to tolerate the forces and torques that they are able to generate, can potentially throw out their arms.[3]

Rehabilitation of the baseball athlete after injury has been well described.[2,11,17,21,24-27] Traditional nonoperative and postoperative rehabilitation programs for these patients involve a gradual restoration of range of motion, strength, muscular endurance, dynamic stabilization, and neuromuscular control.[24,26,27] Often omitted in the description of managing the injured baseball athlete is the transition from the clinic to the field. Traditional rehabilitation exercises cannot reproduce the speed or the joint forces generated during throwing.[6,13,14] The only way to mimic the forces of a baseball throw is to actually throw a ball.[6] Interval throwing programs are progressive, sport-specific regimens that gradually expose an athlete to the demands they will experience upon a return to sport.

Although rehabilitation programs may recommend participating in an interval throwing program before a return to competition,[9,10] there are only a few published descriptions of throwing programs in peer-reviewed literature.[4-7,22] The forthcoming interval baseball-throwing programs have been derived from game data. The purpose of this clinical

Table 1. USA Baseball pitch count recommendations, by age.[23]

Age Group	Pitches (n)
9- to 10-year-olds	50 per game 75 per week 1000 per season 2000 per year
11- to 12-year-olds	75 per game 100 per week 1000 per season 3000 per year
13- to 14-year-olds	75 per game 125 per week 1000 per season 3000 per year

Table 2. Youth pitchers speed and distance: at-risk athletes.[a]

Age (y)	Average		1 SD		2 SD		3 SD		4 SD		5 SD	
	mph	feet	mph	feet	mph	feet	mph	feet	mph	feet	mph	feet
8	40	95	43	109	47	123	50	137	54	151	57	165
9	43	105	47	124	51	142	55	159	59	167	63	185
10	46	123	50	140	54	157	58	174	62	174	66	191
11	48	135	52	157	56	175	60	195	64	215	68	235
12	50	141	55	166	60	191	65	216	70	241	75	266
13	54	164	59	188	64	212	69	236	74	261	79	286
14	60	196	66	225	72	254	78	283	84	312	90	341

[a]Reprinted with permission by Lippincott Williams and Wilkins.[3] Three standard deviations (yellow), 26 athletes out of 10 000; 4 standard deviations (orange), 1 out of 100 000; 5 standard deviations (red), 1 out of 1 000 000.

commentary is to provide a complete set of data-based interval throwing programs and progression instructions to aide the transitioning of injured and uninjured off-season baseball players back to the field. Furthermore, flexible components of the interval throwing program can facilitate individualization. The assumption and expectation is that the pathomechanics leading to injury have been corrected before commencing these programs.

INTERVAL THROWING PROGRAM DEVELOPMENT AND DESIGN

The goal with each throwing program is that upon completion, the athlete will be prepared for the workload encountered during competition at one's preinjury activity level, while minimizing the risk of reinjury. If not properly prepared, an athlete is vulnerable to injury upon return to sports participation. This is true whether the athlete has a throwing-arm injury, a nonthrowing-arm injury, or an injury to any region of the body that has resulted in lost playing time. Therefore, these position-specific interval programs, modified to one's level of play, are not exclusive to baseball players with injuries of their throwing extremities.

Likewise, the uninjured baseball player who is returning to play after an off-season must be prepared for practice. "Too much, too soon" can result in an onslaught of injuries for a team at the start of the preseason. Thus, interval throwing programs are an excellent training strategy for uninjured athletes to prepare for the new season, and they provide coaches with an easy reference for workouts.

The major feature of these throwing programs is that they are data driven. Most interval programs are based merely on estimations of when an athlete should return to play. In this era of evidence-based medicine, it is important that treatment interventions be based on objective data, whenever possible. Each position-specific throwing program is based on game data and so represents a realistic workload that the athlete will experience upon a return to sports participation. This approach helps to ensure the athlete's preparedness and thus minimize the risk of reinjury. As such, this program is practical, functional, and progressive.

Practical

First, equipment needs are minimal and inexpensive; only balls, a field, and a tape measure are needed.[23] Second, the program design was intended to address the short attention span of young athletes; the time to complete the program on any given day is

approximately 45 minutes or less. The intervals that compose each step of the throwing program allow constant reinforcement to improve compliance and reduce boredom. Finally, the throwing programs are thoroughly outlined with detailed instructions for progression. Hopefully, excuses for noncompliance are reduced, and implementation by the athlete may be maximized. After initial instruction, supervision by an athletic trainer, a physical therapist, a physician, or any other member of the medical team might only be necessary to ensure that the athlete understands all instructions.[6]

Functional

Functional throwing programs are ones that reflect the demands of the game. Differences in field dimensions and pitch-count limitations can vary considerably, depending on the athlete's age and level of play. Furthermore, the number, intensity, and type of throws can vary by position. Therefore, it is reasonable to have age- and position-specific throwing programs to meet the needs of each athlete.

Functional Interval Throwing Programs for Pitchers

Game data were collected, including the number of innings pitched, the number of pitches per inning, the pitch mix, and the time between innings.[5,6] The full age spectrum of baseball competitors were evaluated, including 8- to 12-year-olds, 13- to 14-year-olds, and high school, college, and professional players. The analysis revealed that the number of innings per outing and the number of pitches per inning for starters were different across groups, with the 8- to 12-year-old age group and the 13- to 14-year-old age groups pitching significantly fewer innings per outing than the other 3 groups.[6] Although the pitching volume for both age groups was similar, the rules and field dimensions, combined with the need to progress to the high school volume within 2 years, rendered only 1 throwing program for 8- to 12-year-olds ineffective in addressing the needs of the slightly older players.[6] Based on statistical analysis of these data, 3 throwing programs were developed: 1 for pitchers 8 to 12 years old (Appendix 1 available online at http://sph.sagepub.com/content/suppl), 1 for pitchers 13 to 14 years old, and 1 for high school, college, and professionals (Tables 3 and 4).[5,6]

The throwing programs must assist the athlete's progress from inactivity in the off-season to throwing at game volume. To achieve this goal, the throwing programs are divided into 4 distinct and progressive phases: return to throwing, return to pitching, intensified pitching, and a simulated game.[6]

Table 3. Pitcher throwing program for 13- to 14-year-olds.[a]

Phase I	Return to Throwing			Phase II	Return to Pitching
	All throws are at 50% effort				
Step 1	Warm up toss to 60´			Step 4	Warm-up toss to 105´
	15 throws at 30˝				20 fastballs (50%)*
	15 throws at 30˝				16 fastballs (50%)*
	15 throws at 30´				16 fastballs (50%)*
	20 long tosses to 60´				25 long tosses to 105´
Step 2	Warm-up toss to 75´			Step 5	Warm-up toss to 120´
	15 throws at 45˝				20 fastballs (50%)*
	15 throws at 45˝				20 fastballs (50%)*
	15 throws at 45´				20 fastballs (50%)*
	20 long tosses to 75´				25 long tosses to 120´
Step 3	Warm-up toss to 90´			Step 6	Warm-up toss to 120´
	15 throws at 60˝				16 fastballs (50%)*
	15 throws at 60˝				20 fastballs (50%)*
	15 throws at 60´				20 fastballs (50%)*
	20 long tosses to 90´				16 fastballs (50%)*
	Fastballs are from level ground following crow hop				25 long tosses to 120´
Phase III	**Intensified Pitching**				
Step 7	Warm-up toss to 120´	Step 11	(Active rest)	Step 14	Warm-up toss to 120´
	20 fastballs (50%)*		Warm-up toss to 120´		20 fastballs (100%)*
	20 fastballs (75%)*		20 throws at 60´ (75%)		Throws to 1st (100%)
	20 fastballs (75%)*		15 throws at 80´ (75%)		15 fastballs (100%)*
	20 fastballs (50%)*	Step 12	20 throws at 60´ (75%)		10 off-speed pitches (100%)*
	25 long tosses to 160´		15 throws at 80´ (75%)		20 fastballs (100%)*
Step 8	Warm-up toss to 120´		20 long tosses to 160´		5 off-speed pitches (100%)*
	20 fastballs (75%)*		Warm-up toss to 120´		20 fastballs (75%)*
	21 fastballs (50%)*		20 fastballs (100%)*		5 throws to 1st (75%)
	20 fastballs (75%)*		20 fastballs (75%)*		25 long tosses to 160´
	21 fastballs (50%)*		6 off-speed pitches (75%)*	Step 15	Batting practice
	25 long tosses to 160´		20 fastballs (100%)*		100-110 pitches
Step 9	Warm-up toss to 120´	Step 13	20 fastballs (75%)*		10 throws to 1st
	25 fastballs (50%)*		6 off-speed pitches (75%)*		Bunts and comebacks
	24 fastballs (75%)*		25 long tosses to 160´	Step 16	Simulated game
	24 fastballs (75%)*		Warm-up toss to 120´		
	25 fastballs (50%)*		20 fastballs (75%)*		
	25 long tosses to 160´		4 throws to 1st (75%)		
Step 10	Warm-up toss to 120´		15 fastballs (100%)*		
	25 fastballs (75%)*		10 off-speed pitches (100%)*		
	25 fastballs (75%)*		20 fastballs (100%)*		
	25 fastballs (75%)*		5 off-speed pitches (75%)*		
	20 fastballs (75%)*		20 fastballs (75%)*		
	25 long tosses to 160´		4 throws to 1st (75%)		
			25 long tosses to 160´		

[a]Reprinted with permission by Lippincott Williams and Wilkins.[6]

SIMULATED GAME

1. 10 minutes warm-up of 50-80 pitches with gradually increasing velocity
2. 5 innings
3. 22-27 pitches per inning, including 15-20 fastballs
4. 6 minutes rest between innings

*Rest 6 minutes after these sets.

INSTRUCTIONS

A. Baseline/preseason
   To establish a base for training and conditioning, begin with step 3 and advance one step daily to step 14 following soreness rules.

B. Nonthrowing arm injury
   After medical clearance, begin step 3 and advance one step daily to step 16 following soreness rules.

C. Throwing arm—bruise or bone involvement
   After medical clearance, begin with step 1 and advance program as soreness rules allow throwing no more than every other day.

D. Throwing arm—tendon/ligament injury (mild)

   • After medical clearance, begin with step 1 and advance program to step 3 throwing every other day as soreness rules allow.
   • Throw every third day on steps 4-8 as soreness rules allow.
   • Return to throwing every other day as soreness rules allow for steps 9-16.

E. Throwing arm—tendon/ligament injury (moderate, severe, or post op)
   • After medical clearance, begin throwing at step 1.
   • For steps 1-3, advance no more than 1 step every 3 days with 2 days of active rest (warm-up and long tosses) following each workout.
   • Steps 4-8 advance no more than 1 step every 3 days with 2 days active rest (see step 11) following each workout.
   • Advance steps 9-16 daily as soreness rules allow.

Table 4. Throwing program for high school, college, and professional baseball pitchers.[a]

Phase I	Return to Throwing			Phase II	Return to Pitching[†]
	All throws are at 50% effort				
Step 1	Warm-up toss to 60´			Step 8	15 throws at 60´6´´ (75%)*
	15 throws at 30´´				20 throws at 60´6´´ (75%)*
	15 throws at 30´´				20 throws at 60´6´´ (75%)*
	15 throws at 30´				15 throws at 60´6´´ (75%)*
	20 long tosses to 60´			Step 9	20 throws at 60´6´´ (75%)*
Step 2	Warm-up toss to 75´				20 throws at 60´6´´ (75%)*
	15 throws at 45´´				20 throws at 60´6´´ (75%)*
	15 throws at 45´´				20 throws at 60´6´´ (75%)*
	15 throws at 45´			Step 10	20 fastballs (50%)*
	20 long tosses to 75´				20 fastballs (50%)*
Step 3	Warm-up toss to 90´				20 fastballs (50%)*
	15 throws at 60´´				20 fastballs (50%)*
	15 throws at 60´´				25 throws at 60´6´´ (75%)*
	15 throws at 60´			Step 11	20 fastballs (50%)*
	20 long tosses to 90´				20 fastballs (75%)*
Step 4	Warm-up toss to 105´				20 fastballs (50%)*
	15 throws at 75´´				15 fastballs (75%)*
	15 throws at 75´´				25 throws at 60´6´´ (75%)*
	15 throws at 75´´				
	20 long tosses to 105´				

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Phase I	Return to Throwing			Phase II	Return to Pitching†
Step 5	Warm-up toss to 120´			Step 12	25 fastballs (50%)*
	15 throws at 90˝				20 fastballs (75%)*
	20 throws at 90˝				20 fastballs (75%)*
	15 throws at 90˝				20 fastballs (75%)*
	20 long tosses to 120´				20 fastballs (75%)*
Step 6	Warm-up toss to 120´				
	20 throws at 105˝				
	20 throws at 105˝				
	15 throws at 105˝				
	20 long tosses to 120´				
Step 7	Warm-up toss to 120´				
	20 throws at 120˝				
	20 throws at 120˝				
	20 throws at 120˝				
	20 long tosses to 120´				
	Throws at effort level given				
Phase III	**Intensified Pitching‡**				
Step 13	25 fastballs (75%)*	Step 16	20 fastballs (100%)*	Step 18	(Active rest)
	20 fastballs (100%)*		15 fastballs (100%)		Repeat step 14
	10 fastballs (75%)*		5 off-speed pitches	Step 19	20 fastballs (100%)
	15 fastballs (100%)*		5 pickoff throws to 1st		5 off-speed pitches*
	25 fastballs (75%)*		20 fastballs (100%)		20 fastballs (100%)
Step 14	(Active Rest)		5 off-speed pitches*		3 pickoff throws to 1st*
	20 throws at 80´		20 fastballs (100%)		20 fastballs (100%)
	20 throws at 80´		5 off-speed pitches*		3 pickoff throws to 2nd*
	20 throws at 80´	Step 17	15 fastballs (100%)		15 fastballs (100%)
	20 throws at 80´		5 off-speed pitches*		5 off-speed pitches*
Step 15	20 fastballs (75%)*		15 fastballs (100%)		15 fastballs (100%)
	20 fastballs (100%)		3 pickoff throws to 1st*		5 off-speed pitches*
	5 off-speed pitches*		20 fastballs (100%)	Step 20	Batting practice
	15 fastballs (100%)		5 off-speed pitches*		110-120 pitches
	5 off-speed pitches*		15 fastballs (100%)		Field bunts and comebacks
	20 fastballs (100%)		3 pickoff throws to 2nd*	Step 21	Simulated game
	5 off-speed pitches*		15 fastballs (100%)		
	Field bunts and comebacks		5 off-speed pitches*		

[a]Reprinted with permission by Lippincott Williams and Wilkins.[6]
*Rest 9 minutes after these sets.
†Begin steps in this phase with warm-up toss to 120´. All fastballs are from level ground after a crow hop. Finish steps in this phase with 25 long tosses to 160´.
‡Begin all steps in this phase with warm-up toss to 120´. Finish steps in this phase with 25 long tosses to 160´.
**Relievers and closing pitchers can go to step 21 on the next throwing day after completing this step

SIMULATED GAME

1. 10 minutes warm-up of 50-80 pitches with gradually increasing velocity.
2. 5-8 innings for starters, 3-5 innings for relievers, 2-3 innings for closers.
3. 15-20 pitches per inning, including 10-15 fastballs
4. 9 minutes rest between innings

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The amount of time required to complete each phase of the throwing program is individualized and dictated by the type of injury that the athlete sustains as well as by any symptoms in response to throwing. The program begins with short throws at 50% effort and with longer tosses from level ground, to build arm strength and endurance. Depending on the level of play, there are between 3 and 7 steps in the return-to-throwing phase. Once a base has been established, the pitcher progresses to pitching from level ground (2-5 steps), followed by advancement to the pitching mound (3-9 steps). Fastballs are thrown exclusively until the pitcher has advanced to 75% of the expected game volume. Then, the pitcher may begin incorporating off-speed pitches based on one's preinjury pitch preference. After the athlete can complete the final step of the intensified-pitching phase without soreness, the throwing program is culminated with a simulated game, to replicate the demands of competition as accurately as possible.[5,6]

Short toss and long toss are 2 functional elements of each pitcher's programs. The short-toss component employs the principles of adaptation to imposed demands; that is, pitchers must pitch.[5] The long-toss component, rather than reflecting the demands of pitching, is used to develop endurance and arm strength, reduce injuries, and increase speed.[5] A correlation of this concept would be running long distances to improve a sprinter's performance and reduce injury.[5] For the 8- to 12-year-old throwing program, the maximum throwing distance for long toss is based on age and preinjury data. If only pitch speed and age are known, the long-toss maximum distance can be found in Appendix 1B available online at http://sph.sagepub.com/content/suppl.

Functional Interval Throwing Programs for Position Players

Game data were collected for the positional baseball player from 13 years old to college age to confirm whether position- and/or age-specific interval throwing programs were necessary for these athletes.[7] For catchers, the following data were recorded: the number of throws back to the pitcher (60 ft, 6 in), the number of sprints to back up plays at 1st or 3rd base (90 ft), the time in the squat stance, the number of throws other than throws back to the pitcher, the distance of these throws, and the perceived effort of these throws. Infielder and outfielder data included the number of throws, the distance of the throws, and the data collector's perception of each throw effort. The means and ranges per inning and per game were then calculated for each variable of interest.

These data were subsequently used to determine which age and position programs were necessary and to construct the throwing programs. Statistical analysis revealed no significant differences across age groups for either catchers or infielders.[7] Consequently, there are only position-specific throwing programs for these athletes (see Appendices 2 and 3 available online at http://sph.sagepub.com/content/suppl.).[7] Position- and age-specific programs were not needed. There were, however, significant differences among outfielders, which subsequently necessitated age-specific programs for the outfield position. The 13-year-old outfielders had mean throwing distances and high ends of

throwing distance range that were significantly lower than those the other levels of players.[7] Therefore, separate outfielder programs were developed for 13-year-olds and adults (see Appendix 4 available online at http://sph.sagepub.com/content/suppl.).

Progressive

Each throwing program is, by design, progressive. A combination of the number, intensity, distance, and rest time between throws, as well as the type of pitch thrown (when appropriate), advances from step to step. The initiation of throwing for the injured baseball player must be based on the assumption that tissue healing is complete, that the athlete has appropriately progressed with the exercise program, and that a satisfactory clinical examination has been conducted (including range of motion, strength, joint stability, and pain resolution). Once the athlete initiates the throwing program, the medical team must educate the athlete on the importance of following the structured progression. A study by Fleisig et al[15] illustrated the athlete's flawed ability to estimate throwing effort. In a study of healthy pitchers targeting a 50% effort, the athletes generated ball speeds of 85% and forces and torques approaching 75% of maximum.[15] A target of 75% effort achieved speeds of 90% and forces and torques of 85% of maximum.[15]

Advancement through each throwing program is governed by the type of injury that the athlete has encountered and the soreness rules (Table 5).[5-7] The exception is the uninjured athlete who is participating in a throwing program as part of one's preseason preparation. In these instances, progression is dictated by only the soreness rules.[6,7] The type of injury guides program progression. Categories include injuries to areas of the body other than the throwing arm (eg., back, nonthrowing arm), injuries to the throwing arm but not including the joints (eg., bruise), tendonitis, and joint injuries (eg., rotator cuff tear, postoperatively).[6,7] These categories determine at which level the athlete may initiate the throwing program and how quickly progression may occur. The soreness rules guide progression within the throwing program on the basis of an athlete's symptoms.[5-7] Although there are general time frames for tissue healing, the health care provider must be attentive to individual variability in healing rates. Consequently, progression within the throwing program must be individualized. Given the timing and duration of the symptoms, the medical team may be able to minimize the risk of overloading injured tissues, by determining whether a baseball player is ready to progress to the next step, remain at the same step, or drop down a step. In addition, the soreness rules, along with the type of injury, dictate the amount of rest time between steps.[6,7]

Table 5. Soreness rules, all players.[a]

If no soreness, advance one step every throwing day.
If sore during warm-up but soreness is gone within the first 15 throws, repeat the previous workout. If shoulder becomes sore during this workout, stop and take 2 days off. Upon return to throwing, drop down one step.
If sore more than 1 hour after throwing, or the next day, take 1 day off and repeat the most recent throwing program workout.
If sore during warm-up and soreness continues through the first 15 throws, stop throwing and take 2 days off. Upon return to throwing, drop down one step.

[a]Reprinted with permission by Lippincott Williams and Wilkins.[5-7]

The final step of most throwing programs is a simulated game for a given position at the maximum level of play. A true simulated game is derived from actual game data.[8] Coleman et al[12] collected 3 years of data and suggested a game simulation for professional pitchers that controlled for innings pitched, pitches per inning, time between innings, and preinjury pitch mix. The goal was to determine a pitcher's readiness to return after injury. Although Coleman's simulated game is a good tool for establishing game readiness, it did not include a functional progression toward return to play, nor did it address the demands faced by positional baseball players or by athletes competing below the professional level.[7] The combination of age- and position-specific throwing programs, together with simulated games, may be used as criteria to determine return-to-play readiness.[7]

INDIVIDUALIZATION

Data-based throwing programs that have been customized to meet the needs of the individual have the greatest potential to return the baseball athlete to one's preinjury activities, expeditiously and safely. Many characteristics of the data-driven programs promote individualization: age- and position-appropriate programs, progression rate based on the type of injury and the soreness rules, and pitch mixes based on preinjury preferences. The throwing program for the 8- to 12-year-old pitcher is an excellent example of an individualized program, given that the long-toss portion of the program is based on the athlete's age and preinjury pitching velocity or maximum distance thrown. There is, however, ample opportunity for the medical team to further individualize these throwing programs.

Collection of preinjury data is the best method to develop a performance profile and so individualize a throwing program. To develop the programs

described, data from large sample sizes were collected, tested, and implemented for baseball athletes of different ages and positions. The same concept may be utilized for an individual athlete. Ideally, throwing velocity and distance would be documented for 2 consecutive years, because this is reflective of the athlete's biological maturity. In contrast, preseason performance for a single year is more a measure of the athlete's chronological maturity. However, if the medical team and coaching staff have access to performance for a single season, this information should still be used to gauge pitching intensity progression and throwing distance and to determine an appropriate pitch mix during both the throwing progression and the simulated game.

The medical team should take liberty in modifying the throwing programs to address situational needs. The amount of rest time between intervals may be lengthened on the basis of athlete feedback. The intervals themselves may be split in half if the soreness rules do not match the throwing-program phase. These programs may also be utilized after injuries to body regions other than the upper extremities. Ankle sprains and knee injuries are common among baseball players, so they too must undergo a gradual exposure to the stresses associated with sports participation. In these instances, additional sprints, time in the catcher's squat, and fielding time would be appropriate. Although these modifications are not data driven, the medical team should recognize when to modify the throwing program to facilitate an injury-free return to sports.

CONCLUSION

To minimize their injury risk, athletes must gradually and progressively prepare their bodies for the stresses associated with throwing. Such stresses are unique and can be replicated only by throwing a ball. Interval throwing programs are an effective mechanism to accomplish this goal and so facilitate a healthy return to competition regardless of the athlete's age, position, or level of play. As such, the medical team must individualize these programs to meet the needs of each athlete.

Additional tables of interest corresponding to this article are available online at http://sph.sagepub.com/content/suppl.

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