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Examining effects of Franklin Method metaphorical and anatomical mental images on college dancers' jumping height

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A quasi-experimental design was used to assess effects of Franklin Method images on dancers' jump height. Thirteen dancers applied four image interventions while performing first position jumps for vertical height analysis. Mean heights and within-trial jump degradation and variability were examined. A repeated-measures mixed model analysis with covariates was used to assess whether jump heights differed significantly from baseline. Two of the four images showed significant increases in jump height above baseline. A linear time effect was also found over the course of the study. Anecdotal self-reports revealed that there appeared to be no correlation between jump height and imagery rating.

Keywords: imagery; pedagogy; Franklin Method; jumping; dance technique; dance science

Dancers visualize in many ways to support efficient function toward optimal performance and healthy careers. Overby and Dunn (2011, 9) describe visualizing with dance imagery as 'the deliberate use of the senses to rehearse or envision a particular outcome mentally, in the absence of, or in combination with, overt physical movement. The image may be constructed of real or metaphorical movements, objects, events, or processes.' While dance classrooms are abundant with images suggested to support technique and performance, little research has been done to explore how well the imagery and associated concepts support desired outcomes. Dancers must rely on proprioceptive sensations and instructor comments for assurance of success with imaging, and making desired changes in technique can feel disconcerting at the outset. While many people have offered suggestions for imagery application over the last century (Bernard, Steinmuller, and Stricker 2006; Dowd 1981; Krasnow 1997; Tindall-Ford and Sweller 2006; Todd 1937), Eric Franklin has created the most codified, diverse, and extensive framework for imagery application (1996a, 1996b, 2004, 2007). Essentially, he has provided the field of dance with a rich, pedagogical system of imagery application for dance, but no evidence-based research exists to support his hypotheses. By studying some of Franklin's imagery interventions in a quasi-experimental setting, we hope to provide

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evidence of outcomes and how outcomes relate to cognitive, physical, and affective experiences. Certainly dancers' experiences may differ from one another, and from day to day, but if trends emerge that reveal that images have similar effects across participants, then teachers may gain increased understanding, specificity, and agency with choosing images for teaching. Our long-term hope is that research-supported imagery applications will strengthen dance pedagogy to assist in enhanced performance due to improved function. That task looms large because there are many images, image categories, and many ways a body can move. We chose to explore the efficacy of four Franklin Method image interventions assumed to support increased jump height to determine if they do help dancers jump higher. This study presents an exploration of the pedagogy of imagery application for achieving higher jumps with the aim of bridging dance science with classroom pedagogy.

Related literature

A large body of research was conducted over the last four decades revealing the factors that are thought to produce high vertical jumps in athletes, but we could find no reviews of outcomes of single images used to train or improve jump height. Aragón-Vargas and Gross offer an excellent literature review of jumping research noting studies of kinesiological aspects such as: muscle activation patterns, osteokinematics, strengthening, isokinetic analysis, and electromyography (1997, 24–44). By reviewing research on jumping, we can see the evolution of the understanding of what is required for optimal jump height.

Research on vertical jumping performance started with a focus on muscular strength, only to find that improving muscular strength does little, by itself, to help an athlete attain higher jumps (Ball, Rich, and Wallis 1964; Bangerter, 1968; Blattner and Noble 1979; Brown, Mayhew, and Boleach 1986; Cavagna, Dusman, and Margaria 1968; Eisenman 1978; McKethan and Mayhew 1974); however, Perrine and Edgerton (1978) determined that isokinetic knee extension power showed to be highly correlated with vertical jump performance. This correlation seems to be related to Viitasalo and Aura's (1984) hypothesis that the rate of force development is important to achieve high jumping. They determined that a dancer could be strong with a high peak force, but have a poor rate of force development and inferior jump performances. Research evolved to focus on the contributions of successive proximal-to-distal body part initiations in coordination with biarticulated muscle engagement offering additional velocity to the mono-articulating muscles (Bobbert and van Ingen Schenau 1990; van Ingen Schenau et al. 1985). Outcomes revealed a muscle activation order of upper body, upper legs, lower legs, and then feet. Jensen and Phillips (1991) contributed a study exploring absolute velocity and muscle activation and Bobbert and van Soest (1994) and Dowling and Vamos (1993) agreed with earlier studies that showed that the pattern of force application during a jump is more important than the strength and optimal force to jump high, but Bobbert and van Soest found that optimal muscle timing differs across individuals. Their study revealed that all humans, even in optimal performance, do not perform using identical patterns. Research shifted to vertical takeoff velocity and net vertical position of the body center of mass (what dancers would describe as, 'aligning themselves on the vertical axis and getting off the ground quickly with each jump'), which were found to be highly important in gaining necessary forces for jumping high (Aragón-Vargas and Gross 1997; Jaric, Ristanovic, and Corcos

1989). These groundbreaking research studies examined jumping as a physical enactment, a way of studying the body mechanics of jumping. These studies have been conducted on athletes who partake in sports.

Dancers are athletes, but their fitness training involves pedagogy that revolves around imagery (anatomical, metaphorical, and esthetic) and, hence, dance scientists have begun exploring how imagery interventions affect dancers' movements. Hanrahan and Salmela (1990), who examined two types of imagery interventions (local and global) applied to three different dance skills, laid a foundation for associating image qualities, location and direction of image flow, choice of movements studied, and method of evaluation employed. This research revealed relationships between the *développé* and global imagery (imagery dealing with space – inner or outer – relating to the whole of something rather than a specific part), thereby supporting the notion that imagery does indeed facilitate movement. In addition, research by Krasnow et al. (1997) revealed that imagery training in conjunction with dance conditioning produced better results over time than either did alone. These studies laid the foundation for additional imagery research.

Couillandre, Lewton-Brain, and Portero (2008) conducted an imagery intervention study on professional ballet dancers' first position *demi plié*s and jumps to investigate effects of imagery on depth of *demi plié*, jump height, and alignment. Measurements of jump height, maximal vertical acceleration variation, electromyographically assessed muscular activation during knee flexion and extension, and ratio of muscle activity in four muscles of the lower limb yielded no significant relationships between images and *demi plié* depth or jump height. Dynamic alignment did improve, which was attributed to increased hamstring activity stabilizing the pelvis during the *demi plié* preparation for the jump. Researchers delivered the images as a string of discursive images emphasizing, in the following order, kinesiological principles, self-tactile aid, weight sensing, muscle sensing, lines of direction of movement, and metaphor. While the images did not produce an increase in jump height, they did demonstrate the potential for imagery techniques to optimize alignment of the *demi plié* and jumps. They expressed that, while the whole of this imagery string did not produce all the desired outcomes, individual imagery interventions should be conducted so that dancers and dance teachers could more precisely apply imagery applications in classrooms, studios, and wellness labs.

By examining how imagery relates to desired outcomes in dance technique, theorists and researchers are beginning to provide anecdotal and statistical evidence of how images support various dance movements (Ahonen 2008; Bobbert and van Ingen Schenau 1990; Castaner and Torrents 2009; Dowling and Vamos 1993; Franklin 2002, 2004; Hanrahan 1994; Jensen & Phillips 1991; Laws and Petrie 1999; Nordin and Cumming 2006; Pandy and Zajac 1991; van Ingen Schenau et al. 1985). The outcomes of this body of research are beginning to provide deeper understanding of a teaching and learning relationship that can be considered a student-centered approach to using imagery to improve technique. A visual motor behavior rehearsal model by Suinn (1990) proposes that imagery should be a holistic process that includes a complete reintegration of experience. This model includes visual, auditory, tactile, emotional, and kinesthetic cues or images. His research reveals that physiological responses can indeed result from athletes' use of mental imagery. While the notion of teaching movement by employing imagery is not new (Franklin 1996a, 1996b; McKenzie and Howe 1997; Nordin and Cumming 2007, 2008), the dance science community has much to do to explore the outcomes of imagery application in dance pedagogy. It seems vital to consider that an individual's personal and somatic histories likely play a factor in how images are perceived and embodied, even as the images themselves consist of variables independent of the individual. Based on a substantial review of research, neurophysiologist Jeannerod (1994) argues that visual imagery and visual perception can be translated to motor physiology, and that images have similar properties to corresponding motor preparations and therefore have functional relationships to the image and a parallel role in the generation of movement. These foundations bring us to our study.

Hypotheses

The purpose of this study was to explore individual images assumed to increase jump height. By having dancers apply the images in a quasi-experimental study, we can discover if the images tend to contribute to increased jump height. They can also share how they perceive the images' effects on their jumping, which may reveal relationships between the images and experiential qualitative outcomes. Four hypotheses were tested in the study. H1: Each of the chosen images will improve jump height. H2: The metaphorical, whole body images ('whole body is a spring' and 'central axis is a rocket booster') will produce the highest jumps for this population because the images seem more generative of the power necessary for whole body integration that is needed for jumping. H3: Images of 'whole body is a spring' and 'central axis is a rocket booster' will cause fatigue more quickly than the images of 'feet stretching into the sand' and 'spinal curves lengthening.' H4: Participant experiences with images will correlate with jump height.

Methods and materials

Participants

To obtain participants, we asked ballet teachers at a university to recommend dancers whose jump height was deemed in need of improvement. Participants were not told why they were recommended for the study. Eleven female and two male college dance majors, free of current injury, provided informed consent and volunteered to participate. Participants were regularly studying contemporary dance, ballet, and jazz, and were in the second year of a four-year Bachelor of Arts degree in dance. Each completed a demographic intake form regarding age, height, number of years dancing, year in college, and history of past injuries (see Table 1).

Materials

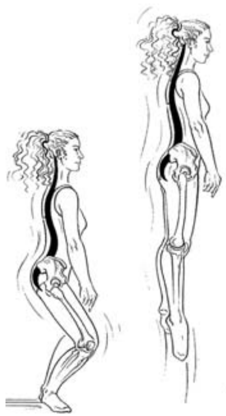
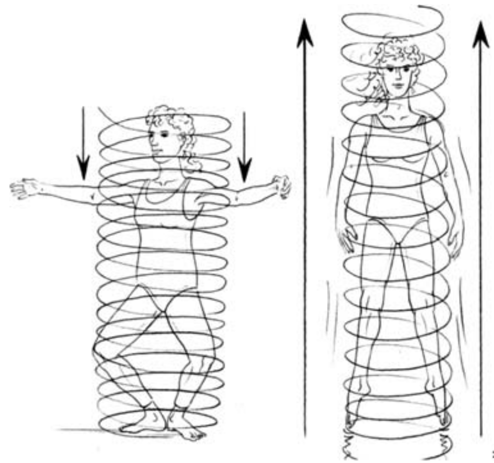
We chose to study images by Franklin that are kinetically charged and that could be delivered verbally and visually with the aim of achieving increase in jump height (Franklin 1996a, 2004). Each intervention consisted of three components: a brief narration of what to image, an 8½″ × 11″ illustration of a dancer embodying the image, and an abbreviated self-talk for dancers to say silently while jumping. Franklin drew two of the illustrations, 'central axis is a rocket booster' and 'whole body is a spring,' for this study. See Table 2 for narrations, illustrations, and self-talk for each of the four interventions.

Table 1. Demographics and jump measurements over all trials for each participant.

Participant	Sex / Age (yr)	Wt (kg)	Ht (cm)	Exp.(yr)	Mean (SE) jump measurements[a]			Change in mean height (in.) from baseline[b]			
					Height[c] (in.)	Decline* (in./jump)	Variability (%)	Rocket	Sand	Spine	Spring
1	F/20	50	62	8	12.5 (0.09)	−.045 (.017)*	4.0 (0.27)	*2.70*	1.02	1.21	2.05
2	F/29	66	67	25	13.0 (0.10)	−.096 (.019)*	5.0 (0.34)	0.44	−0.45	−1.21	*0.62*
3	F/18	66	65	5	10.1 (0.08)	.013 (.023)	4.7 (0.44)	*2.07*	0.93	1.86	1.28
4	F/19	58	70	13	10.7 (0.07)	−.056 (.010)*	3.6 (0.23)	*1.54*	−0.49	0.52	0.91
5	M/19	74	72	2.5	12.4 (0.15)	.011 (.036)	7.1 (0.77)	2.50	*3.46*	3.37	2.22
6	F/21	73	68	18	13.0 (0.10)	−.040 (.026)	3.9 (0.33)	1.33	0.86	0.54	*1.56*
7	F/19	59	61	2	9.3 (0.07)	−.045 (.022)	6.9 (0.55)	*1.26*	0.76	0.86	0.63
8	M/19	64	67	12	13.0 (0.11)	.034 (.013)*	4.6 (0.39)	*−0.84*	−1.80	−0.96	−1.23
9	F/22	70	65	8	11.8 (0.09)	−.097 (.014)*	4.3 (0.36)	1.15	*1.57*	0.78	1.43
10	F/18	56	70	13	10.6 (0.08)	.013 (.008)	4.0 (0.24)	1.10	0.00	0.59	*1.39*
11	F/20	52	62	8	9.3 (0.11)	−.082 (.016)*	3.9 (0.29)	0.23	*2.07*	0.47	−0.10
12	F/19	69	69	5	10.2 (0.13)	−.045 (.012)*	4.2 (0.21)	2.39	*2.85*	1.40	1.96
13	F/19	58	60	16	9.4 (0.07)	−.050 (.012)*	4.6 (0.52)	1.29	1.41	*1.68*	1.40
Mean (female)	20.4	61.5	65.3	11	10.8	−.048	4.46				
Mean (male)	19.0	69.0	69.0	7.3	12.7	.023	5.85				
Mean (all)	20.2	62.7	66.0	10.4	11.2	−.037	4.79				

[a]SE = standard error of the mean. *n* ranged from 133 to 150 for the mean overall heights. $n = 10$ for jump slope and jump variability (except $n = 9$ for Participant 3).
[b]Each participant's best change is italicized.
* = mean jump decline is significantly different from zero.
[c]Overall height is calculated after pooling all data for that participant.

Table 2. Images, concepts, and three forms of delivery.

	Spinal curves lengthening and deepening	Central axis is a rocket booster	Whole body is a spring	Feet stretching into the sand
1. Long description:	Think of the spinal curves lengthening as you jump and deepening resiliently as you land	Imagine your central axis is extended all the way from the top of your head down to the floor and your body organized around this center. When you jump, ride that axis like a rocket booster shooting up into space	Imagine elasticity everywhere in your body. Your whole body is a coiled spring. Imagine the spring compressed before you jump. Then let the coiled spring shoot open explosively when you jump	Imagine you are standing on sand on a beach. When you jump, stretch your feet so fast and hard that your toes lengthen through the sand beneath you. Image this fast and energetic
2. Drawing of image:	 †	 *	 *	 ‡
3. Self-talk:	"Long spine, deep spine"	"Rocket"	"Compress, release"	"Push through the sand"

*Drawn for the study by Eric Franklin. †Franklin (2004). ‡Franklin (1996a).

Table 3. Images, classifications, and hypothesized outcomes.

Image	Imagery category	Spatial configuration of image	Body part initiation and directionality of image	Hypothesized outcomes
Whole body is a spring*	Metaphorical (or Indirect)†	Inner§	Global (Whole body)§	Energized rebounding so jumps will feel effortless, resulting in higher jumps.
Central axis is a rocket booster*	Metaphorical (or Indirect)†	Inner to outer§	Proximal-to-distal (Whole body)§	A strong central, downward force that will result in higher jumps.
Feet stretching into the sand*	Anatomical–metaphorical (or Direct)†	Inner to outer§	Precise (Local) and Distal§	Improved alignment and quick foot control making jumps feel lighter, resulting in higher jumps.
Spinal curves lengthening and deepening**	Biological–anatomical‡ (or Direct)†	Inner§	Precise (Local) and Proximal§	Improved *plié* preparation and aligned long spine resulting in higher jumps.

*Franklin (1996a).
**Franklin (1996b).
†Paivio (1971).
‡Dowd (1981).
§Hackney (2007).

Imagery classifications

For concept organizing, we classified the images by imagery type, spatial configuration, and body part initiation. Metaphorical imagery is not directly related to anatomy or kinesiology, but supports a movement process or movement coordination (Paivio 1971). Anatomical–metaphorical imagery involves a body part and a metaphor, but is anatomically equivalent in function (Paivio 1971). Biological–anatomical imagery is an experiential form of imagery that is very precise, and dancers are thought to respond well to anatomical images if they have some background in anatomy (Dowd 1981). Spatial imagery is a type of focusing imagery that creates a specific locus of concentration, either inside or outside the body that is fundamental for good proprioception and discovery in the body (Hackney 2007). Body part initiation is a type of spatial imagery that signals to the mover where to place emphasis for initiation of movement (Hackney 2007; Hanrahan and Vergeer 2000–01). See Table 3 for classifications and origin of corresponding concepts.

Measures

A video camera and motion capture technology were configured in a space for jumping. Participants' jump heights were measured by placing markers on the greater trochanter and filming each series of jumps with a digital video camera (Canon XL1S, Tokyo, Japan) at ~30 frames per second. The optical axis of the camera was placed

Figure 1. Participant jumping while imaging ‘whole body is a spring.’

on the dancer’s right side, perpendicular to the sagittal plane of the body. As the participant sprung from her/his original starting position (measured on straight legs) to the highest point of each jump (see Figure 1), the jump height was calculated using motion analyzer software (Logger Pro, Vernier, Beaverton, OR, USA) measuring the changing distance between the marker on the greater trochanter and a landmark directly beneath on the floor. Quantitative data were examined to determine (a) whether or not imagery may support increased jump height and (b) which image may best support jump height overall. Upon completion of each jumping trial, participants were asked to describe aloud their experiences having applied the image during the intervention. We scribed the qualitative comments, coded descriptions, and grouped trials by themes of ‘positive,’ ‘neutral,’ or ‘negative’ so the outcomes could be integrated into statistical analysis (Lincoln and Guba 1985).

Protocol

A repeated-measures design was used to structure the assessment of the baseline and intervention jumping trials. Participants performed baseline measures (without intervention) twice at the beginning of the study, followed by eight intervention trials; four image interventions were applied twice during those eight trials. For each trial, participants usually arrived warmed up from having just taken technique class, but if the class did not utilize jumping or if participants did not come directly from class, they warmed up by performing *pliés*, *tendus*, and *relevés* followed by a series of jumps to adequately prepare for jumping trials. We asked participants to jump, with arms *en bas*, eighteen times so that any jump height patterns would be revealed, and also to highlight effects of fatigue brought about by the imagery interventions. Jumps 4–18 were used in the analysis.

Participants jumped on a sprung wooden floor that was marked with lines showing the sagittal and horizontal planes running through the body, marked as such to assist in placement for the video camera. Because jumps can be performed with a downward or an upward emphasis, participants were told to jump emphasizing upwardness in order to achieve the same style of jumping during all trials. This information was given before the imagery intervention was revealed.

Statistical Analyses and Methods

Initial summarization of data was performed by grouping data by image type, participant, or trial (visit) number, and then averaging the pooled data. Average jump heights for participants, for each trial over time, for each jump within trials, and for each image were computed and presented in tables or figures. A more formal and robust alternative to this pooling method that takes into account trial number, jump number, jump decline, and jump variability is *mixed model analysis*. A linear mixed model approach for within-subject (repeated-measures) fixed factors and random covariates was performed in SAS version 9.2 for Windows (using PROC MIXED). The use of mixed models over the more traditional approaches using general linear models [e.g. analysis of variance (ANOVA)] has several advantages. First, mixed models handle both unbalanced designs (where the number of participants in each combination of conditions is not constant) and missing individual data points without having to lose an entire block of data, as occurs in traditional ANOVA models. Second, traditional models impose rather severe restrictions on the structure of the within-subject correlations (so-called 'sphericity' conditions), and violations of these restrictions may confound the interpretation of tests of significance (e.g. the p-values will be smaller than they should be) even if correction factors are applied; assumptions of these conditions are not necessary with mixed models.

The mixed model analysis incorporated two fixed within-subject effects, 'Image Type' and 'Jump Number'; one random within-subject effect (a constant term); and no between-subject effects. In addition, the time of each trial (nominal visit number) was incorporated as a continuous within-subject linear covariate with both fixed- and random-effect components. Both dancer body height and average measured height during baseline conditions were considered as additional covariates. All second-order interaction terms were initially included in the full model, and then removed if found to be nonsignificant and if their removal resulted in a better model fit, as assessed by the Akaike Information Criterion (AIC).

The mixed model requires a within-subject covariance structure to be specified. The covariance structure accounts for how variables measured at different times within the same participant are correlated (therefore increasing the power to detect differences due to the remaining explanatory factors). 'Jump Number' (with 30 levels, representing 15 jumps in each of two trials) was the first within-subject factor. As appropriate for factors that represent the passage of time, a first-order autoregressive [AR(1)] covariance structure was used for this factor (this type of structure assumes that the correlation between any two time points decreases with their separation). 'Image Type' was the second within-subject factor; as no a priori relationship between image types was assumed, an unstructured (general) covariance was used for this factor, requiring the correlation of all possible pairs of this factor to be estimated uniquely. Simultaneous type-III tests for all fixed effects were conducted, and effect sizes for all fixed and random effects were estimated. In addition, differential effect sizes were assessed for each of the four image types compared to baseline (the no-image condition), using the Dunnett–Hsu correction for multiple comparisons. Effect sizes for image type were estimated at the mean jump number and trial number (i.e. they were computed from the point of view of what would be observed during the middle of the study [between the fifth and sixth trial] and during the middle of a trial [at the eleventh jump]). Therefore, their values may differ slightly from the pooled averages as presented in the initial summary analysis.

Statistical significance was set at 5%. Other standard statistical tests were used and described as appropriate, including one-way ANOVA, Pearson's correlation coefficient ('Pearson's *r*'), and the chi-square test for independence. Data from the first three jumps of each trial were not used in the analyses, as detailed in the results section. When measures pertaining to a trial as a whole were analyzed (e.g. self-reported trial ratings, or characteristics of the entire sequence of jumps within the trial), the average jump height for each trial was used as the unit of data and basis for comparison.

Results

Demographics

Table 1 lists demographic data for the 13 enrolled participants. All participants successfully completed two no-image (baseline) trials and two trials of each of the four image intervention conditions (except Participant 3, who missed one no-image trial). Out of a possible 2340 jump height measurements (13 participants $\times$ 10 trials $\times$ 18 jumps/trials), only 32 jump height measurements were missing, due to either a missed trial (one participant) or problems with analyzing individual jumps with video-capture technology.

Jump results

The overall mean jump height across all participants and all jumps was 11.2 in. (see Table 1). The mean jump heights for participants ranged from 9.3 to 13.0 in. Participant height did not correlate with average jump height (Pearson's $r = 0.434$, $p = 0.139$). Mean heights representing a 'typical' trial were computed by averaging jump heights over all trials and participants; values are plotted in Figure 2. Mean jump heights start at about 10.8 in., rapidly increase to about 11.3 in. by the fourth jump and remain constant for several jumps, and then slowly decline to values seen at the beginning. The initial increase over the first three jumps was observed in many individual participant trials, and was interpreted as a 'warm up' period. The slow decline over the latter half of the trial possibly reflects fatigue.

During various trials, we observed a wide range of consistency in jump height. As an example, individual trials from two participants are presented in Figure 2. It is readily apparent that Participant 4 (who was experiencing the 'sand' image during that trial) was jumping fairly erratically, with an over 3 in. difference between her highest and lowest jump (this was one of the most erratic sessions observed). In contrast, Participant 5 (experiencing the 'spine' image) was much more consistent,

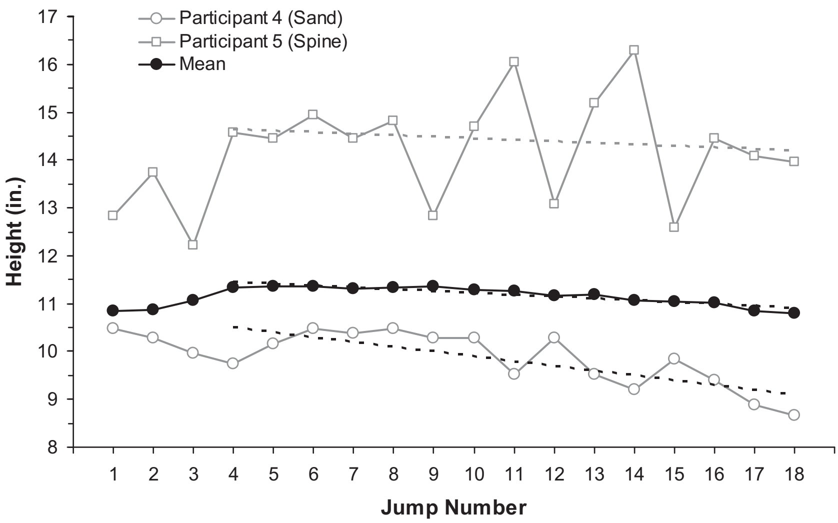


Figure 2. Heights by jump number within session, for two example sessions and for overall mean.

Table 4. Number of participants in each condition, and mean jump height, for each trial.

	Image						
Trial	Baseline	Rocket	Sand	Spine	Spring	All	Mean (SE) jump height (in./jump)
1	13					13	10.3 (0.14)
2	6	1	1	3	2	13	10.3 (0.10)
3	2	1	4	2	4	13	10.9 (0.10)
4		6		4	3	13	11.1 (0.12)
5	2	4	4	1	2	13	11.0 (0.12)
6	1	2	4	4	2	13	11.3 (0.11)
7		4	1	4	4	13	11.4 (0.13)
8		4	4	1	4	13	11.9 (0.12)
9	1	1	6	2	3	13	11.5 (0.12)
10		3	2	5	2	12	11.8 (0.12)
Total	25	26	26	26	26	129	

with relatively little variability from jump to jump (this was one of the 'smoothest' trials observed).

Both the slow decrease in height over time and the overall inconsistency can be quantified for each individual trial as the 'decline' and 'variability,' respectively. To calculate the jump decline for each trial, we fit a standard least-squares regression line through the heights, from the fourth to the final jump. (The first three jumps were discarded in this and all subsequent analyses, so as to avoid the observed warm-up period, which was highly variable.) Examples of these regression lines are given in Figure 2. Values for the declines are in units of inch per jump.

The jump variability in each trial was characterized (after again ignoring the first three jumps) using a statistical measure known as the coefficient of variation of the root-mean-square (CV-RMS). This is a useful quantity that characterizes variability as a percentage of the mean value, after subtracting the effect of the systematic linear decrease in values (the decline). A higher variability score means the jump profile was more erratic for that trial.

The average decline and variability was calculated for each participant (see Table 1). Average declines ranged from −0.97 to 0.034 in./jump, with an average of −0.048 in./jump, indicating most, but not all, participants exhibited a decrease in heights during the course of a trial. (While these numbers may seem small, recall that the decline measures change *per jump*. Over the course of 15 jumps, the average decrease for an entire trial exceeded 0.5 in).

Finally, we computed the mean jump height for each trial, averaging over all individuals and images (see Table 4). There appeared to be a constant upward drift in mean jump heights over the 10 trials during the course of the study, increasing from 10.3 to 11.8 in., which may reflect both the front-loading of baseline interventions at the beginning of the study, and any possible 'learning effect' occurring over time. We address this again below. Results were statistically analyzed using two approaches, a simple pooled data method, and the method of mixed model analysis.

Comparisons between images: pooled data approach

Changes in mean jump height from baseline were calculated (see Table 1) for each participant under each image condition. Five participants had their largest change from baseline following the 'rocket' image, and four had the largest change after 'sand' (including the participant with the highest overall change, at 3.46 in.). Three participants improved the most with the 'spring' image, and only one participant showed the best improvement with the 'spine' image. The differences for each image from the average baseline height were 1.3 (rocket), 0.9 (sand), 0.8 (spine), and 1.0 (spring) in. (see Table 5).

Using a one-way ANOVA with Tukey's HSD post-hoc test for pairwise differences adjusted for multiple comparisons, image type had a significant effect ($F = 25.2$; df = 4, 1916; $p < 0.0001$ for main effect of image type), and the average

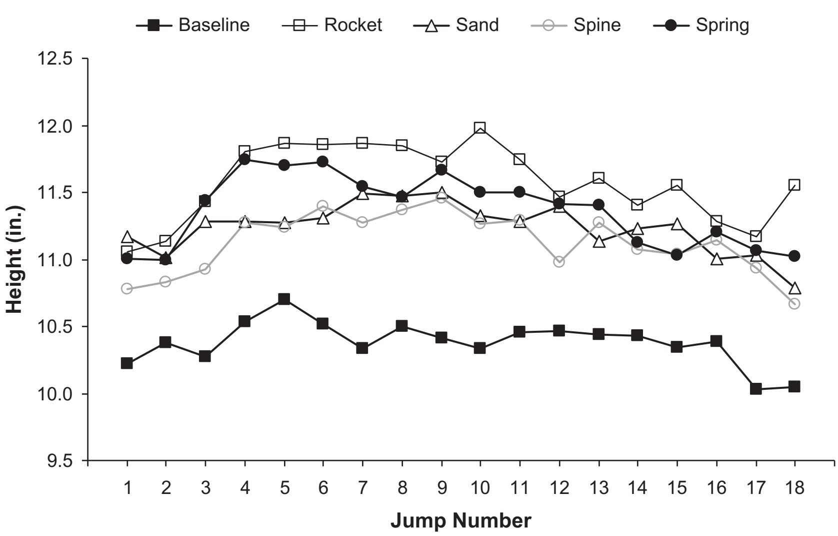


Figure 3. Session jump heights for each image condition, averaged across all participants.

jump heights of each of the four images were all significantly higher than the baseline condition (see Figure 4); in addition, 'rocket' heights were significantly higher than both 'sand' and 'spine' heights.

The average jump variability was consistent between image conditions (see Table 5 and Figure 3). The mean jump decline for each image ranged from −0.028 ('baseline') to −0.050 ('spring') in./jump, suggesting some images might induce more fatigue than others. However, the declines are highly variable from trial to trial, and the differences among image type were not statistically significant (ANOVA, $F=0.52$; df = 4124; $p=0.72$).

Table 5. Jump measurements and subjective ratings over all trials, by image.

	Mean (SE) measurements[a]			Rating counts		
Image Type	Height[b] (in.)	Decline (in./jump)	Variability (%)	Negative	Neutral	Positive
Baseline	10.4 (0.11)	−.0276 (.0131)	4.70 (0.40)	–	–	–
Rocket	11.7 (0.09)*	−.0468 (.0145)	4.61 (0.23)	3	6	17
Sand	11.3 (0.09)* &	−.0291 (.0149)	4.75 (0.31)	2	9	15
Spine	11.2 (0.08)* &	−.0348 (.0125)	4.96 (0.36)	16	6	4
Spring	11.4 (0.09)*	−.0495 (.0144)	4.41 (0.31)	8	6	12

[a]SE = standard error of the mean. n ranged from 373 to 387 for height. $n=26$ for jump decline and jump variability (except $n=25$ for baseline).
[b]* = significantly different from the baseline conditions.
& = significantly different from the rocket image type.

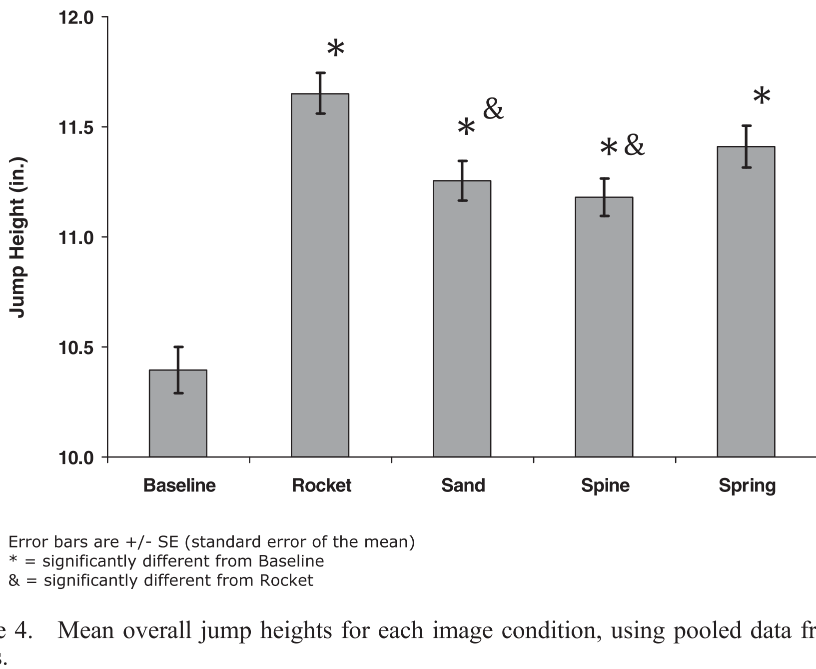


Figure 4. Mean overall jump heights for each image condition, using pooled data from all jumps.

Table 6. Mixed model results.

Effect	Estimated effect size	*F* value[a]	*p*-value
Image[b]	–	5.92	<.001
Baseline	10.67 in.		–
Rocket	+0.88 in.		<.001
Sand	+0.41 in.		0.214
Spine	+0.46 in.		0.101
Spring	+0.71 in.		0.003
Jump Number	–	2.70	<.001
Trial[c]	0.094 in./visit	3.45	0.088

[a]The *F*-test numerator/denominator degrees of freedom for the Image, Jump Number, and Visit factors are, respectively, 4/1862, 29/1862, and 1/12.
[b]The effect size for baseline is the estimated actual height as would be achieved in the middle of the study (between visits 5 and 6) in the middle of a trial (on the eleventh jump). The effect sizes for the four images are the additional jump height due to the image, above that experienced at baseline. *p*-values for Image were adjusted for multiple comparisons and are significant below the 0.05 level.
[c]The effect size for Trial represents the additional incremental jump height that is added on each subsequent visit.

Comparisons between images; mixed model approach

Image Type and Jump Number were included as repeated (within-subject) fixed factors, and trial number was included as a random continuous covariate to model any systematic effect over time. The most parsimonious model providing the best fit to the data (determined using the AIC) contained only main effects and no interaction terms, and did not include participant body height or average baseline height as covariates. The results are summarized in Table 6.

The covariate of trial number was included in order to capture a possible linear time effect, representing a continuing increase in jump height regardless of type of image. Although not a highly significant factor on its own ($p = 0.088$), the effect was retained as it strongly contributed to the overall model fit and explains an important part of the variance in this study. The effect size of 0.094 in. per trial represents an additional increase of approximately one-tenth inch in jump height at every subsequent trial, so that over the 10 trials of the study, about one inch in height is added. This effect might be attributed to factors such as history, learning, training, maturation, motivation, attitude, testing, selection-testing effect, or comfort level.

The Image factor, then, estimates the unique contribution of each individual image, and it was significant ($p < 0.001$) in the model. In order to gage the individual gains due to each image, we computed, for all four images, the 'estimated effect size,' which measures the additional jump height (in inches) contributed by each image as compared to the height achieved during baseline (which was estimated to be 10.67 in.).

The mixed model estimates that the 'rocket' image added 0.88 in. to jump heights, and the 'spring' image 0.71 in. Both these effects were statistically significant ($p < 0.001$ and $p = 0.003$, respectively, after adjusting for multiple comparisons). The 'spine' image was not significant ($p = 0.101$), adding an estimated 0.46 in.; and the 'sand' image was also not significant, with 0.41 in. added ($p = 0.214$). Thus, the 'rocket' and 'spring' images had strong effects upon the jump height, even after taking into account any overall systematic increase in jump height over time.

A source of variability in the data is the fact that jump heights decrease over the course of a trial of 18 jumps, as discussed earlier with regard to the concept of 'jump decline' and possible fatigue. Thus, it is not surprising that the within-subject Jump Number factor was a significant factor in the model ($p < 0.001$), and including this factor is an important part of determining whether the Image type is also a significant factor. Both jump decline and jump variability were formally tested in the mixed model framework as secondary response variables. No statistically significant relationship to image type was found. The data in Table 5 indicate a possible relationship between jump decline and image type that may be uncovered more fully with a higher sample size.

Correlation of self-ratings to image type

We also considered another measured variable in this study, participants' self-reported anecdotes. Verbal narratives of each trial were coded and grouped by themes reflecting 'positive,' 'neutral,' or 'negative' experiences and resulting ratings were tabulated for each image type. Each image was rated 26 times (twice by each participant). The 'rocket' and 'sand' images were rated almost exclusively as either neutral or positive (see Table 5). The 'spring' image received eight negative ratings and 12 positive ratings. The remaining image, 'spine,' was perceived either neutrally or negatively, receiving only four positive ratings out of 26. The dependence of the subjective rating upon the image type was statistically significant ($\chi^2 = 35.4$, df $= 11$, $p < 0.0001$), which indicates that participants did have a preference for the type of image being presented. The preferences did not appear to correlate to actual jump height, but may be linked to changes in other experiences that occur during the trials.

Despite the participants' self-reported preferences, the subjective ratings for each participant do not correlate overall with participants' actual jump heights (e.g. the grand average of the jump heights for all images remains between 11.3

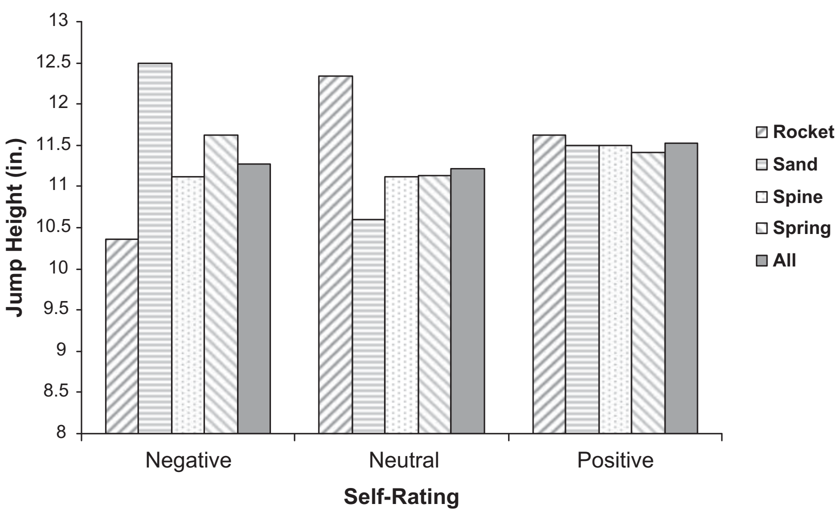


Figure 5. Mean change in jump height following each intervention, categorized by self-assessed quality of experience (positive, neutral, or negative).

and 11.5 in. regardless of rating category, see Figure 5). When broken down by image type, the trials that were rated positively had almost identical average heights for each image type; negatively rated trials, on the other hand, had average heights that varied over a 2 in. range, with the ‘rocket’ image yielding the lowest jump height (when rated negatively). While these patterns are interesting, we caution that the averages are based on relatively low numbers of participants, especially for the negative ratings. (Note that because participants rated a given trial as a whole, and not its individual jumps, the trial-averaged jump heights were used as the basis for comparison.).

Discussion

Aligning quantitative and qualitative data

We assessed four Franklin Method images for their ability to support increased jump height and the relationship between dancer’s perceptions and personal outcomes. After various analyses, the ‘rocket’ and ‘spring’ images appeared to be particularly effective at improving jump height; both of these metaphorical images also happen to be whole body images. It seems then that metaphorical images may tend to generate whole body engagement, while anatomical images may tend to incite a more precise, local initiation. Our first hypothesis, that each of the chosen images will improve jump height, was not clearly supported, as the ‘sand’ and ‘spine’ images produced only marginal improvements in jump height (under the mixed model analysis). The second hypothesis, that metaphorical, whole body images will produce the highest jumps, was supported, and points to the need for images to incite the power needed for whole body integration. The third hypothesis, that the ‘spring’ and ‘rocket’ images will cause fatigue more quickly than the others, was not supported; while a measureable fatigue effect existed, it had roughly the same value for all image types. Finally, the fourth hypothesis, that participant experiences with images will correlate with jump height was not statistically supported; however, a preference for certain images was observed. The highest number of negative responses did occur for a low-effect image (‘spine’).

It is interesting to note that the ‘sand’ image, while not consistently increasing jump height for the group as a whole, seemed to have supported marked improvements for some individuals, including the second highest individual jumping trial overall and the second largest change in average jump heights for four participants. The ‘sand’ image was also anecdotally rated second highest. These aberrations from the group outcomes indicate there is potential in the ‘sand’ image to support jumping height, but that some other supplementary image might be needed for this image to be uniformly successful. Statistical analysis revealed that ‘spring’ produced the second highest jumps overall; however, participants’ anecdotal experiences revealed mixed reactions to the image. Similarly, participants reported many positive experiences with ‘sand,’ which ranked as the second-most preferred image, but jump heights with ‘sand’ were only third highest. Certainly proprioceptive adjustments may have indicated inconsistency and loss of control, and hence participants’ negative comments may have been related to erratic performance experiences, while positive comments may have been related to perceived consistency. Further analysis of alignment in connection to ‘spring’ and ‘sand’ might reveal what attributed to these positive comments. Despite these reports, observed jump consistency, as measured by the variability of jump heights within a trial, was remarkably stable across image types on average.

Suggestions for classroom application

Even after the overall increase in jump height over time was accounted for, the 'rocket' and 'spring' images had strong effects upon jump height. The 'spine' image as initiator of the successive proximal-to-distal body part initiations, as noted by Bobbert and van Ingen Schenau (1990), Pandy and Zajac (1991), and van Ingen Schenau et al. (1985), does point toward coordination of a muscle activation order of upper body, upper legs, lower legs, and feet, but the 'spine' image did not bring about the forces necessary to increase height. Dowling and Vamos (1993) have hypothesized that jump height could be increased if athletes generate large torques late in the movement, which the 'spinal curves lengthening and deepening' image seemed not able to incite alone. Focusing intently on only the spinal curves may have even inhibited the chain effect, as it were, that results when a proximal initiation connects to a mid-limb and then to a distal initiation. While the 'spine' image was not a strong supporter of jump height, information detailing how the spine moves during jumping might be suited to educating the biomechanics of jumping in a kinesiology lab in which jumpers need to understand where a strong rate of force development for high jumps initiates, as was previously found by Viitasalo and Aura (1984).

In general, metaphorical images that encompass whole body integration best supported increased jump height. Both 'rocket' and 'spring' are metaphorical images that relate to the whole body, but the generally accepted 'rocket' concept, which moves from proximal-to-distal initiation was more successful than the global action of 'spring.' If dance teachers are aiming to increase dancers' jump height, trying either the 'rocket' or 'spring' images would likely have efficacy. While the 'sand' image offers many positive experiences, we must explore this image further to better understand its pedagogical efficacy.

Precautions toward validity

While the sample size was small, by using valid, selective statistics and controlling for several variables, we were able to suggest trends in performance with these imagery interventions. Because the study involves humans, no cause and effect relationship between jump height and image type can be definitely proved; however, the trends and correlations that exist are suggestive of possible routes for further study and innovations in dance pedagogy.

While there was a good measure of control on our part, variables in the daily lives of participants may have affected the outcomes. Participant's motivation levels in relation to various human and temporal factors could not be controlled, but each trial was carefully narrated using a script, and no leading comments were stated that could have tainted any aspect of the jumping trials and intervention deliveries. One aspect of a repeated-measures design that is impossible to control is that learning over time may occur because participants experience dance training outside the study. In addition, the study itself could actually coach the participants to be better at jumping due to experiencing imagery interventions over time. We attempted to account for this in the protocol. Participants were purposely not told that we were assessing jump height, only that we were interested in effects imagery had on jumping technique. Had the participants known that jump height – which is essentially an image in itself – was being studied, then that image might have diminished the effect of the imagery interventions.

Limitations

The number of participants is too limited for making broad generalizations; however, the results of this study of 13 participants represent a generalized theme that represents how college dancers of a broad-based curriculum of study in a liberal arts university might respond to images used to enhance jump height. Also, learning occurs with or without images, so all results from the study must be regarded with caution and consideration as all humans are continuously changing.

Conclusion and implications for further research

Time for discussion in a technique class is limited, and teachers must strategically choose tactics for information delivery. When teaching jumps, dance teachers have the complex task of guiding a group of dancers to find optimal execution of dynamic alignment, torque, and peak force while relating esthetically to music and intricate connecting steps. Using images that facilitate these kinesiological factors could assist this complex task. Succinct images are especially handy in the dance classroom because a large amount of kinesiological information, which could otherwise take a long time to explain discursively, can be delivered concisely to support cognitive, affective, and psychomotor learning. The responsibility for choosing images that are effectively student-centered requires that teachers understand how images and movements are embodied by various populations and levels of dancers. Knowing which images seem to support higher jumps is only a small facet of exploration of imagery for dance technique training; however, it is the beginning of creating theory that can support imagery application to strengthen dance pedagogy.

Dance teachers use imagery to teach; therefore, teachers need research outcomes to better understand how dancers experience dance pedagogy. Dance science research is informing the dance field about what occurs in the body during optimally efficient technique; however, in order for dance instructors to assist dancers in achieving optimal jumps, dance science research must bridge to pedagogical delivery methods that aim to support desired outcomes. Anecdotal experiences revealed participants' perceptions of success indicated evidence of potential improvements in technique that lie outside the scope of jump height. Further research into positive experiences not correlating with increase in jump height may reveal how images affect other aspects of jumping technique. Finally, evidence of 'learning effect' occurring over time indicates the need for future studies to include either a control group or repeated baseline measures throughout the course of the study. The slight 'learning effect' that did occur in this study might inspire future research to explore how well images increase and retain 'learning effect' over a prolonged period.

By researching a large framework of images and dance movements based on various aspects of movement, dance pedagogy may be supported by dance science to provide images that are functionally equivalent to desired physical outcomes and appropriate for the technical and imaging levels of our dancers. Research outcomes may aid us to become even more informed about why, how, when, in what sequence, and how often we should apply various image interventions. By following the lead of generations of dance imagery pedagogues, Franklin has provided many images for us to explore toward improving dance pedagogy. We *can* bridge imagery hypotheses and dance science so dance pedagogy will serve dancers even better than it has so far. This study is only the beginning of our long journey toward deeper understanding of the body–mind relationships between imagery and dance technique.

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